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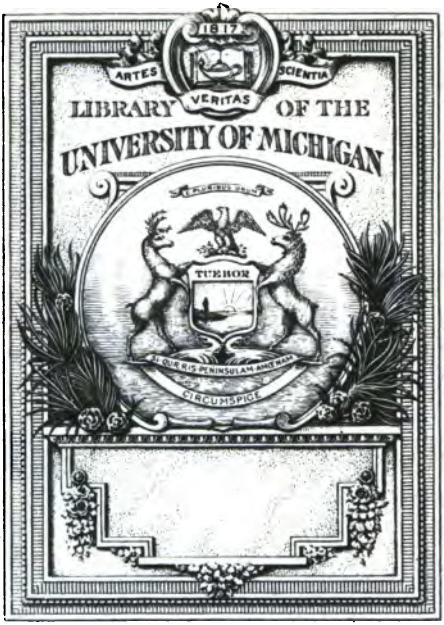
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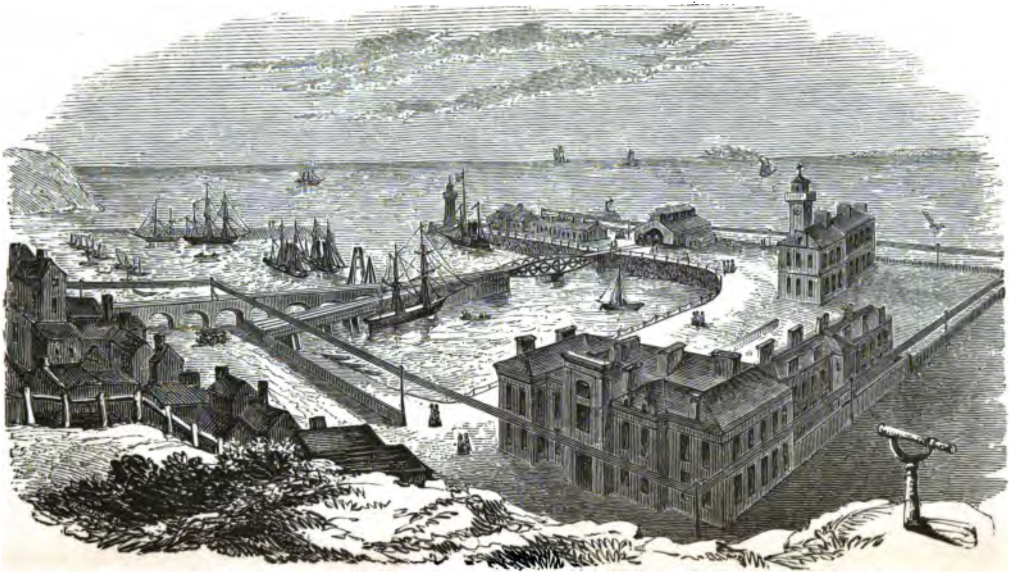
MANIPULATIONS

IN THE

SCIENTIFIC ARTS.

PART V.

ELECTRIC TELEGRAPH MANIPULATION.



Folkstone Harbour.

ELECTRIC TELEGRAPH MANIPULATION:

BEING

THE THEORY AND PLAIN INSTRUCTIONS

IN THE ART OF

TRANSMITTING SIGNALS TO DISTANT PLACES,

AS PRACTISED IN ENGLAND,

THROUGH THE COMBINED AGENCY OF

ELECTRICITY AND MAGNETISM.

BY
incent
CHARLES V. WALKER,
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AUTHOR OF ELECTROTYPE MANIPULATION, &c. &c.

ILLUSTRATED BY WOODCUTS.

SECOND THOUSAND.

LONDON:
PUBLISHED BY GEORGE KNIGHT AND SONS,
MANUFACTURERS OF CHEMICAL APPARATUS AND
PHILOSOPHICAL INSTRUMENTS,
FOSTER-LANE, CHEAPSIDE.

1850.

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LONDON:
PRINTED BY STEWART AND MURRAY,
OLD BAILEY.

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PREFACE.

The extreme rapidity with which the wires of the Electric Telegraph have, in a few short years, ramified themselves throughout the land, is singularly characteristic of the invention itself. But a few years ago all we knew of this wonderful invention was by report: it had an existence in the cabinet of the philosopher, and no further; and when, after a while, a friendly hand was held out to it, and it was led a little forth, it was looked upon with a suspicious eye, and few were bold enough to take it manfully by the hand. Slow, therefore, though its first steps were, they were firm and they were onward steps. Wheatstone, in his study, had well investigated the relation between electric force and magnetic and magnetised bodies; he had seen theoretically, and he soon proved experimentally the value of these relations for transmitting signals to distant places. Associated with him was Mr. Cooke, a gentleman of great practical knowledge, and of much perseverance. To him especially we are greatly indebted for having practically carried out on the large scale what they had together proved true upon the small. With his own eye and his own hand he directed all the operations in the actual erection of the first telegraphs; he literally lived, for the time being, upon the railway, making a railway carriage his shelter by day, and his couch by night.

Since this time the progress has been so rapid, that the Englishman has suddenly found himself in the midst of a most extensive system of telegraphs, before he has scarcely had breathing time to discover *what* they can do, and *how* they do it.

My object has been to furnish him with this information. I have endeavoured to condense into the following pages a tolerably comprehensive view of the conditions that have been combined in the construction of the Electric Telegraphs at present existing in England. I am aware that many other forms of telegraph, in addition to those in question, have been described in this country; but the majority of them have not yet been applied at all, and others of them have not been used to such an extent as will enable us to determine the position they may ultimately occupy in the general system.

Had my limits allowed me, it would have been interesting to have had before us a tabulated sketch of all the Electric Telegraphs that have been proposed, it would have been very instructive to have passed progressively from the ingenious but unpractical plans of the earlier inventors to the very perfect system of the present day, we should have seen fresh light continuously breaking forth, and difficulties gradually vanishing.

As it is, I have exceeded the limits I had at first purposed, being desirous of furnishing sound information as to the uses we make of the wonderful invention of which we have become possessed.

My example of a system of telegraphs is taken from the South-Eastern Railway Company's lines, which doubly serve my purpose, inasmuch as they are very fully used for Railway service, and are extensively used by the public; and, having had charge of them from their first erection, I am well able to bear witness to the capabilities of such a system.

As this little *Manual* may find its way into the hands of many, both at home and abroad, who have not seen a Telegraph Railway, I have thought it well to have sketches taken upon the spot of some of the general features presented by our arrangements, both without doors and within.

Had I had space for anecdotes, I could have filled page after page with incidents, illustrating the practical value of the Electric Telegraph, far exceeding any that have yet reached the ears of the public. A single day's work of our seventy-seven instruments would be a curious document. But enough may be gathered to illustrate the extraordinary powers of that mysterious *entity* termed electricity,—an entity which we can hardly call a *thing*, for, as yet, it has eluded our grasp,—we have not been able to seize upon it and separate it from matter: and which we would fain term a *property*, but even here we see not clearly all its relations. Familiar though we have become with its operations, I can never see a signal transmitted without being lost in admiration at this wondrous creation,—which moves we know not how, and acts we know not why; but which is conveying our thoughts far away so truthfully that we, at times, almost forget that it is mere wood and metal before us; and, absorbed in what is passing, imagine the telegraph instrument endowed with vitality, and actually itself holding converse with us.

CHARLES V. WALKER,
Superintendent of Telegraphs to
South-Eastern Railway Company.

TONBRIDGE,
March 1st, 1850.

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ELECTRIC TELEGRAPH MANIPULATION.

1. *Introduction.*—In the treatise on "Electrotype Manipulation," we were chiefly concerned in studying the action of voltaic currents in their passage through aqueous solutions of certain metallic salts. Such solutions, when thus treated, suffered decomposition, and rendered up their elements according to well ascertained laws. By taking advantage of these laws, we found it a very easy matter so to arrange our apparatus as to extract from the solution the metal it contained, and to congregate it into any prescribed form, and in a compact mass.

2. Voltaic currents have other actions besides the one in question; to some of which we then referred in the introductory chapter. The property, upon which the construction of Electric Telegraphs depends — viz., *the relation between voltaic currents and magnetism*—was not mentioned at that time. It is essential to our present purpose to have some general knowledge of this relation; and as we proceed we shall become acquainted with the three important instruments that are associated in the construction of an Electric Telegraph, — the VOLTAIC BATTERY, the GALVANOMETER, and the ELECTRO-MAGNET.

3. VOLTAIC BATTERIES. — The motive power, or the source of the force employed to transmit signals is very simple, and very manageable. It consists of nothing more than *zinc*, *copper*, and *diluted sulphuric acid*, with con-

taining vessels and pure siliceous sand, the latter material being passive, and mainly employed to prevent the spilling of the liquid.

A voltaic combination may be made variously; but in all cases requires a *triad*, or combination of three things, one at least of which must be a liquid; the other two are, for practical purposes, generally metals; and such are the triads mostly employed—the combinations of two liquids and one metal giving out but little force.

4. To enumerate all *possible* voltaic combinations would be to sum up all the varied alternations and combinations, that could be made out of almost all the simple and compound bodies found in the laboratory of the chemist; but this would take us widely from our purpose. To enumerate the many *practical* voltaic combinations—by which term I mean such as conveniently furnish abundant supplies of the force in question—would form a little treatise of itself. I have described a few of them in "Electrotype Manipulation;" the others may be found in most of the recent treatises, that embrace voltaic electricity. Leaving, therefore, the curious reader to seek elsewhere for any further information he may require on this subject, we are able for our present purpose to be satisfied with the description of one of the simplest combinations; for it so happens that in practice a simple combination has been found superior to any other. To quote my own description of a single voltaic pair, as given in the work just now named:—

"If a piece of zinc and another of copper be attached one to each end of a wire, and the two be then placed in a vessel containing water, acidulated with sulphuric acid, it will constitute a simple or *single voltaic pair* IN ACTION.

"The action is dependent on the different chemical affinity of the liquid for the respective metals: it will dissolve the zinc rather than the copper; in other words, the water (which is well known to consist of the two gases, oxygen and hydrogen, chemically combined) is decomposed; the *hydrogen* makes its escape at the surface of the *copper* plate in the form of gas; the oxygen *combines* with the zinc and forms an *oxide of zinc;* this oxide unites with, and is dissolved in, the sulphuric acid, forming *sulphate of zinc.* Actions analogous to this occur in *all* voltaic combinations. The exciting liquid has a *greater* affinity for one metal than for the other. The former is termed the *positive* metal, the latter, the *negative.*

"During the continuance of the chemical changes already described, a transfer of electricity is quietly taking place between the two metals. The positive electricity passes *from the zinc through the liquid to the copper;* and then continues its course along the wire, by which the metals are joined, to the zinc again. If the wire is broken, the transfer of electricity is interrupted, and the chemical effects, so far as electricity is concerned, cease; hydrogen is no longer evolved from the copper plate, and the zinc (if it is pure or amalgamated) ceases to be dissolved."

5. From this it may be seen that when the combination is duly formed, the force—the *voltaic* force—may be called into existence or made dormant, according as the connection between all parts of the triad is complete or interrupted. This may be still further illustrated, by regarding the three things arranged in order as the three sides of a triangle—the zinc being one side, the copper one, and the acid water one. So long as the triangle is complete, the sides being all continuous, and all touching at the corners, as thus Δ (of which the left side may do for the copper, the right for the zinc, and the base for a stratum of acid water); while thus the voltaic force is

called into being, and moves in continuous course around the triangle; and, under the present condition, the direction corresponds with that of the hands of a watch in their ordinary motion. But the moment either side of the triangle is divided,—be it the zinc, the copper, or the liquid,—or the moment either is cut off from the others by being separated at the corners, the force ceases to move. For instance: if a piece of ivory, or wood, or glass, or any substance through which the force cannot pass, is interposed between the metals at the apex of the triangle, all action is arrested; but, allowing the ivory still to remain, we may restore the action by holding the respective ends of a piece of wire, one against the zinc, the other against the copper. Under such circumstance, the wire becomes endowed with new properties, which, even on this small scale, may be detected by very ordinary tests; but by somewhat increasing the scale, and by adopting measures to multiply its effects, they become manifested in a very marked manner. One of the peculiarities of a wire thus circumstanced is, that it possesses magnetic properties; it can *convert* iron or steel into a *magnet*, and it can *produce motion* in steel already *magnetized*. We shall see presently how to manage the wire, and in what way to multiply and magnify the force it possesses so as practically to produce these effects, which, indeed, are the two effects required in our electric telegraphs. The wire acquires these properties whether it be short or long—an inch or a mile; but the effects are modified according as the length varies. The wire in all cases is to be regarded, as in fact it is, as an *obstacle* to be overcome; and the *longer* it is, and also the *finer* it is, the *greater* is the obstacle. This obstacle or resistance does not at all influence the actual *rapidity* with which the force moves, and this is very important to us now: it merely reduces the *quantity that moves*, and thus diminishes the effect. Also, whatever may be the value of the force in any one part of the circuit, it is the same in every other part; and hence, if in any part of the circuit the size of the wire is increased, the general resistance is diminished, and *more force* passes in *every part* of the circuit in a given time. If the wire that joined the two metals in the little illustration before us were bent thus Λ, the force would pass up one side to the apex and down the other; but if another equal sized wire were added crosswise to the above, as thus A, part of the force only would pass by the apex, the rest would take the shorter course; and, as a whole, more would pass in this case than in the last. If the cross-piece formed with the others an equilateral triangle, two-thirds would pass by it, and one-third by the apex.

6. A single triad was found sufficient for the majority of electrotype purposes; but the work now to be done, and the great distance that intervenes between the *force* and the *work*, requires a succession of these triads. If slips of zinc and copper are riveted in pairs, and are so placed in a series of wine-glasses that the zinc of each pair is in one glass, while its copper is in the next,—each glass having in it a copper of one pair and a zinc of another pair, the metals not touching, and the glasses containing acid water,—we have a voltaic series. By connecting the two ends of the series with a wire, as before (§ 5), the force circulates; and now we can effectively overcome a greater obstacle than with one triad; that is, we can interpose a much longer length of wire, and yet obtain an available force throughout every part of the circuit. The difference between a single combination and a series of similar combinations may be expressed by equations. The equation for our little triad is $F=\frac{E}{R}$; F being the force in

circulation, E the actual value, or electro-motive power, of the particular combination employed, and R the resistance of the three sides of the triangle,—the zinc, the copper, and the acid. When a connecting wire is employed, its resistance is to be added, and the equation becomes $F=\frac{E}{R+r}$; r representing the resistance of this wire; and hence the greater the resistance, or value of r, the less is the value of F. When we increase the number of the series, we multiply the electro-motive power in the same ratio; but we also multiply the resistance R of each triad by the number in series; and, still leaving the connecting wire in circuit, the equation becomes $F=\frac{nE}{nR+r}$; n being the number of cells.

The value of this equation exceeds the last, because r, or the resistance of the wire, has not been altered with the rest, and the equation represents a greater force; and we are able to multiply r by n before we reduce the equation to the former value: in other words, we are able to put a greater length of wire in the circuit, and still to have the same effect. Accordingly, therefore, as we require a longer circuit r, the greater would be the number n of the series. Experiment alone determines these relations in each case. I should here mention that, while the resistance is in *direct* action to the *length* of the wire, it is in *inverse* ratio to its *sectional area;* and the same is true of the resistance of each triad. So that to give the equation all its parts, we express it thus: $F=\frac{nE}{\frac{nRD}{S}+\frac{nl}{s}}$;

D being the distance between the zinc and copper plates, S their sectional area, l the length of the connecting wire, and s its sectional area. So that as E, n, S, or s increase, the force *increases;* but as R, *r*, D, and *l* increase, the force *diminishes.*

7. *Telegraph Batteries.*—We have in England applied the very inappropriate term *batteries* to a series of voltaic combinations, and such, therefore, we will call them. Our telegraph battery consisted of a strong trough made of teak wood or of oak, generally 30 in. long by 5½ in. wide; and divided into twenty-four cells by partitions of slate, giving for each cell a thickness of about 1¼ in. We have also smaller troughs of twelve cells, shown in Fig 3, § 23. The whole affair is made water-tight, with cement or marine glue. The plates are 4½ in. by 3½ in., the zinc being $\frac{3}{16}$ in. thick, and are connected together in pairs by inch-wide slips of copper riveted to each. A single zinc begins the series, as in the figure, and a single copper ends it. The upper ends of the pairs are varnished, for the sake of cleanliness, and as a protection against corrosion. The pairs of metals are placed astride over the slate partitions, all the zincs facing one way. The cells are then filled to within an inch of the top with siliceous sand; the sand enables us conveniently to transfer the charged batteries from place to place; for we put in only enough acid water to saturate the sand. It also serves to moderate any untoward action that might arise between the acid and the metal. Mr. W. Fothergill Cooke, the patentee, introduced this plan. The acid solution is one part good sulphuric acid, and fifteen water. I prefer increasing the number of plates for any given amount of work, and using a weaker solution, to employing stronger solution with fewer plates. The zinc and copper plates at the ends of the series are respectively secured to the ends of the box by brass terminals, from which wires are led to the telegraph apparatus. According to the distance between stations, we vary the number

of cells; for the short groups of ten or fifteen miles, we use twenty-four cells; from Tonbridge up or down the line, forty to sixty miles, we have forty-eight cells; Dover to London, seventy-two cells. We have in these cases more force than we actually need; but we are thus provided against any loss that may occur through failure or defective *insulation;* of which we shall say more presently.

8. *Amalgamation.*—The zinc of the batteries is amalgamated, or well impregnated on its surface with mercury. In practice, this is accomplished by washing the zinc plates in acid water, and dipping them into a trough of mercury, where they are allowed to remain for a minute or so. They are then placed so as to drain off the superfluous mercury. I prefer giving them a second acid bath, and another mercury bath. They are then ready for use. When they become old and exhausted, they are returned to head-quarters, where they are taken to pieces, and the metals well scoured; after which the zinc plates are re-amalgamated for further use.

9. New batteries, when carefully put together, will, with care, do duty for six or eight months, when the work is not very heavy; and by washing the sand out with a flow of water, and refilling them, they have frequently remained on duty ten or twelve months, or even more, without having been sent in for re-amalgamation. In a lecture delivered before the members of the Royal Institution on May 29th 1847, I gave a list of seventeen such batteries from various telegraph stations, taken at random, with the number of weeks each had served; by referring back to this, I find—

2 had worked	24	weeks.
3	25-6-7	„
2	32-4	„
2	35	„
4	36	„
1	38	„
2	41-2	„
1	52	„

The telegraphs on the SOUTH-EASTERN RAILWAY, of 180 miles and 47 stations, are worked with 2,200 pairs of such plates; and the whole telegraph system in the United Kingdom employs about 20,000 pairs.

We have seen that the piece of *ivory* interposed at the apex of the triangle *arrested* the force, and the *wire restored* it. The ivory and the metals are types of two classes, into which all bodies are divided—*conductors* and *non-conductors* of electricity. There are good and bad conductors, and good and bad non-conductors,—or, as the latter are sometimes called, *insulators*. We employ various specimens of each class in the erection of telegraphs; the conductors to convey our force to its destination, the insulators to prevent its deviating from the path marked out. We now proceed to the means of converting the force to our purpose.

10. GALVANOMETERS.—The mutual relation spoken of between the voltaic force and a magnet is of such a character that they deflect each the other, and tend to take a position at right angles to each other, or across, thus + ; for instance, if the voltaic force (which has been, under such circumstances, called a *current*) were moving from east to west, the position of equilibrium for the magnet is in the direction north to south, and if the strength or force of the current were rightly adjusted to the power and weight of the magnet, and one or other of them were free to move, this relative position would be obtained. If, on the one hand, the magnet be heavy, powerful, and fixed, and the current be traversing a slender wire, so poised as to be free to move, the current will move, and carry with it the wire, into a position at right angles to the direction of the magnet; if, on the other hand, the magnet be small and lightly poised, like a compass needle, while a strong current passes near it along

a stout fixed wire, the magnet will be the moving body, and will take the crossed position, as before. In either case, the result is the same; the current and the magnet tend to rest at right angles to each other. In applying this principle, there are practical objections against allowing the magnet to be the fixed body to act upon the wire as a moving body; so that for useful purposes — and many such arise from this relation,—the wire that conveys the current remains fixed, and deflects a light and delicately-poised magnetized needle.

11. And the *direction* in which this deflection takes place follows a certain known law, being this way or that, according as the direction of the current is varied, or as the observation is made upon the north or the south end of the needle. One case, as illustration, will serve as a key to all, *mutatis mutandis*. Fancy yourself in the centre of a large room, with magnetized needles in all directions around you, and in all positions—some on pivots, pointing horizontally north and south; others suspended on delicate horizontal axes, and hanging in the direction of the dip, being nearly vertical; others roughly suspended and hanging quite vertical; some on the floor, some suspended from the ceiling, others on stands, others on the wall. Then suppose a powerful voltaic current to *descend* from the roof and pass through you from head to foot to the floor,—the effect on the needles would be that every one, no matter what its position or mode of suspension, would be so affected that if you *looked at it* its *north* end would have moved more toward your *right* than it was before. If the needles were not marked, you have merely to observe which pole goes to the right, under circumstances analogous to these, and you may be sure it is the north end. So, again, you have merely to observe whether the electric current deflects the north end of the needle to the right or to the left,

and you at once know whether it is ascending or descending.

12. To return to a single needle near a single current; let A B (Fig. 1) be a stout slip of metal, having a magnetized steel needle (N S) suspended behind it, and made to hang vertically when at rest. If, now, a current is made to descend the metal, from A to B, in the direction of the arrow, the needle will be deflected into the position N S; its north end moving to the right as you look at it. As the force of the current is increased, the deflection increases, until the needle attains the direction N S, at right angles to the current; at which position it will remain, whatever further power may be given to the current. If the piece of metal were to be continued on and bent into the shape of the letter U, as shown by the dotted lines, and the current were not carried away at B, but led onward and up in the direction of the dotted arrow to C, then the portion of the current B C would just as much act on the needle as does the portion A B; and since it is *ascending*, the north pole (*looking* at it *from* the current B C) would move to the *left*. But this is the same *actual* direction as it was moved by A B; so that the whole effect of the two portions of the current is to increase the deflection of the needle.

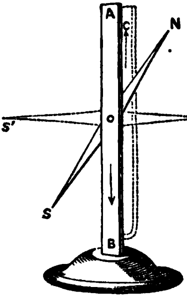


FIG. 1.

13. *The Multiplier.*—By continuing this process, that is, by causing the current to pass many times about the needle, we increase the effect. This is practically accomplished by employing copper wire covered with cotton or

silk, and making with it several convolutions upon a frame round the needle; such an instrument has been called, from its making the force in its course act many times on the needle, a multiplier,—and, from its inventor, *Schweigger's multiplier*,—and is commonly constructed with the needle and coil horizontal. According to the uses to which it is to be applied, the *multiplier* is constructed with a greater or less length, and of thin or thick wire; a short length of thick wire being used for strong currents, and a long length of very thin wire for feeble currents; that is, a strong current requires to be passed fewer times round the needle; to be multiplied, in fact, fewer times to produce its effect, than does a weak one. The instrument is usually fitted up with a graduated circle; and the amount of deflection gives an idea of the relative value of the force, and hence it has been termed the *galvanometer*. But the comparative value of different forces is not in proportion to the mere angle of deflection, even in the most simple cases.

The comparative values of forces may be obtained indirectly by several processes, to some of which we will refer.

14. *Jacobi's Galvanometer Compass* consists of a single stout copper wire passing immediately beneath a two-inch magnetized needle; it is fitted with a graduated circle. It cannot be employed for feeble currents. The relative value of voltaic forces is obtained by observing their respective angles of deflection indicated by the needle, and *multiplying the sine of the angle by its tangent*. These values are obtained, by inspection and a little calculation, from trigonometrical tables; but, for the first 20° or 25° of the quadrant, these comparative values are very nearly in proportion to the *squares of the angles*; which, in such cases, may be employed without much sensible error.

15. *The Tangent Galvanometer*, in its simplest form, differs from the preceding, in that, instead of a wire, a metal ribbon, not less in width than four times the length of the needle, is employed for conveying the current beneath the magnetized needle. Where the character of the current is such that this arrangement can be employed, the expression of the value of the force becomes more simple, being in proportion to the *tangent of the angle*. This can be found by mere inspection, without calculation, from tables of natural tangents. Practically, the wide metal band is continued round the needle, and the *tangent galvanometer* becomes a metal hoop, a foot or a foot and a half in diameter, for conveying the current, with a very short magnetized needle placed on a stand, with its centre accurately in the centre of the hoop. If silk-covered wire is continuously wound in form and place of the hoop, the instrument becomes more sensitive. For the more delicate cases, to which this is not applicable, we have—

16. *The Sine Galvanometer*—which, like the others, has a compass-needle and a graduated circle; but is provided with a *multiplying coil* of covered wire, the length and diameter of which may be suited to the amount of force under examination. The *coil is movable on its axis*. The needle and coil are to be placed in the magnetic meridian; when the current is circulating and the needle is deflected, the coil is to be *moved after the needle;* and when it has reached it, and they both coincide in direction, the angle is to be taken. The value of the forces is *in proportion to the sine of the angle*, which is obtained by mere inspection of a table of natural sines.

17. *Ohm's Method* has a fixed coil, and a compass-needle suspended by a fine wire or a cocoon filament.

When the needle has been deflected, the suspending thread is twisted, until the needle is brought back to its former position. The value of forces with this instrument is proportionate to the *angle, or number of degrees of torsion*, through which the thread has been twisted back, and which are indicated by an attached index.

18. *Fechner's Vibrations* may be read from either form of multiplier. Place the galvanometer so that the needle pointing north and south, the coil shall point east and west; make the needle oscillate, and fix upon any convenient number of oscillations; observe the time occupied in making these oscillations, when one current is compared with another, and the intensities or values are *inversely as the square of the time.*

Although these methods, each in its own place, may give the relative values of the forces in action for the time being, we must not overlook the fact, that, as the wire of each galvanometer presents of itself a *certain amount of resistance*, a less amount of force circulates when the galvanometer is included in the circuit than without it; and, as this resistance bears *no fixed relation* to the other resistances, it cannot be estimated *à priori*, and requires other calculations, into which we cannot enter here. We may express it by g, and insert it in its proper place in the equation (§ 6). Thus: $F = \frac{n\,E}{n\,R + r + g}$, where it is seen to reduce the effect *more*, as the other resistances are *less*.

19. *Nobili's Astatic Galvanometer* — so called from having *little or no directive power*,—has two magnetized sewing needles, one within and the other above the coil, with their poles in reverse directions, and suspended by a cocoon filament. It may be made very sensitive. For instance, Matteucci used one having 3,000 convolutions of

pure copper wire, $\frac{1}{160}$th inch in diameter. A triad of two *apparently* clean *platinum* plates, immersed in *distilled* water, give a deflection. This last is the type of the galvanometer employed for the electric telegraph.

20. *The Telegraph Galvanometers* have had the coil $6\frac{1}{4}$ inches long, 2 in. wide, and $1\frac{3}{4}$ in. thick; it is filled with cotton-covered copper wire, $\frac{1}{100}$th in. in diameter. The coil is vertical, and has one $3\frac{1}{2}$ in. needle within, and with its north end downward; and the other, as in Nobili's, outside and in front, with its north end placed upwards, and serving as the index needle, by which we read the signals, and which is visible on the face of the instrument, Fig. 14 (§ 90), and Fig. 15 (§ 104); the coil is shown in Fig. 3 (§ 23). This galvanometer was at first employed in all instruments; but experience having shown that the pendulum vibrations of so long a needle could not keep pace with the very rapid rate at which signals can be transmitted and read, a shorter needle has been substituted in the recent instruments, and a smaller coil of finer wire.

21. *The Diamond Needle.*—The short inner needle was introduced by Mr. Holmes, in the form of a rhomboid or diamond, $1\frac{1}{8}$th in. by $\frac{7}{8}$ths in. The outer or index needle is made of talc. The coil is proportionately short, and its wire is finer, being about $\frac{1}{130}$th in. in diameter. The deflections of this system may be made much more rapidly than those of the old form; it is much more sensitive, and is very *void of oscillation*, producing almost a dead beat. The laws of magnetism having taught us that an elongated form is the best calculated for the favourable development of magnetic force, I was led to think, that, for the same weight of metal otherwise arranged, we might accumulate more magnetism than with the rhomb; and I made experiments with this in view.

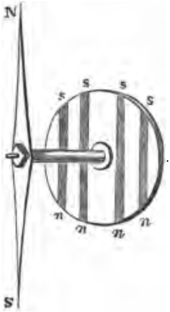


FIG. 2.

22. *The Compound Needle*, as shewn in Fig. 2, was the result. It consists of a very thin ivory disc, 1¼ in. in diameter, sustaining several highly magnetized short needles, *s n*, *s n*, firmly secured on either or both sides of the disc. This compound needle occupies the place of the rhomb within the coil. The index needle, N S, is three inches long. I have made it of steel, worked exceedingly thin and magnetized. The action of the compound needles is very satisfactory. I have used them for a long period in London; and with them the despatches were taken at the rapid rate elsewhere described (§108). In addition to their higher directive power, I presume that they will be found less disposed to part with their magnetism under lightning shocks (§ 84) than are the rhombs: this, indeed, is the chief objection to the rhombs.

However, whichever form of needle be employed, it is made to deflect to the right or left one or more times, by sending one or more currents in this or in that direction along the wire: we shall proceed to describe the mechanism by which this is accomplished.

23. TELEGRAPH INSTRUMENT.—Having studied the properties of the Galvanometer, and described the structure of such as have been employed in our English telegraphs, we are prepared to examine the mode of mounting them for use, and to look into the mechanical adjustments, by means of which the voltaic force is rendered subservient to our will, to produce such and so many galvanometric deflections, as shall serve our purpose; and to produce them rapidly.

The instruments to be described are the inventions of

Messrs. W. Fothergill Cooke, and Charles Wheatstone, F.R.S. They are of two kinds: the one, in which a single galvanometer is employed; the other, in which there is a pair of galvanometers. The former will serve our present purpose; as the mechanical adjustments of the latter are merely the double of this. I have removed the case from the instrument in order to give a clear view of all the essential parts; and have engraved a back view of it (Fig. 3) with the battery E attached as if for use; and the circuit of

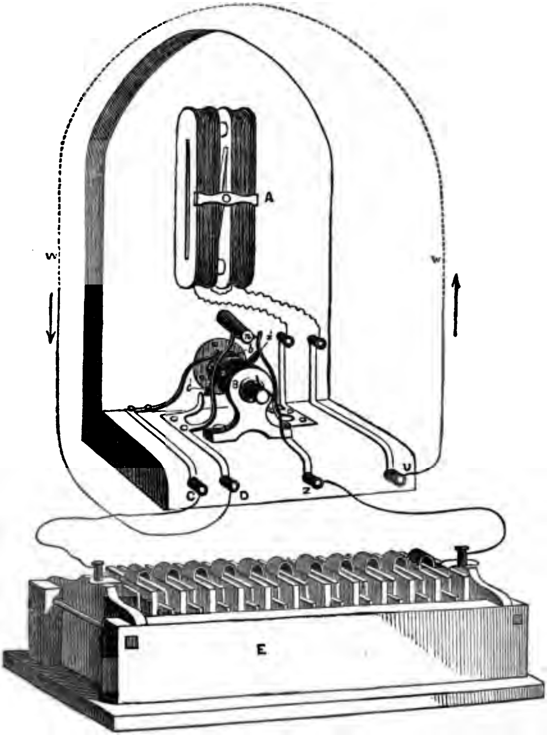


FIG. 3.

the galvanometer A completed by the wire W W. The front view is given elsewhere (Fig. 15. § 104).

24. The instrument is possessed of a two-fold character; it is *passive*, or ready for receiving signals from another instrument; it is *active*, or ready for transmitting signals to another instrument. By describing first how it is fitted for *receiving* signals, and then how it is arranged for *transmitting* them, we shall be better able conveniently to analyze it, and to comprehend its general structure. The frame of the coil B is of brass, or (which is in many respects better) of polished wood or of ivory; it is screwed upon the face of the instrument, which face is a brass plate varnished on the inner side. Looking at the coil, a short wire from its right-hand end comes to a screw terminal, which latter, by a slip of brass neatly laid on the instrument case, is connected with another terminal U. The left-hand end of the coil comes also to a terminal, from which a slip of brass descends to a brass plate, here partly hidden; but its form may be gathered from a similar plate, visible on the left side. These twin plates are in metallic connection by means of the two upright springs, plainly shewn in the drawing. The springs are of stout steel, and press strongly on two points in a short insulated brass rod *n*, which is screwed into the wooden framework of the instrument. The left-hand plate is connected with the terminal D, also by a slip of brass. If, now, the two terminals U and D are connected by a wire W W, the circuit will be complete, as follows: from the terminal U into the coil at the right-hand side; out of the coil, at the left side, downwards to the right-hand plate; up the right-hand steel spring, across the brass rod *n* to the left-hand steel spring; downward, by this spring, to the left-hand plate, thence by the slip of brass to the terminal D, and thence by the wire W W to the terminal U, whence we

started. If now the wire from U went up the line of railway, and the wire from D down the line, and the circuit were in some way kept complete on the large scale, as it has been here described on the small scale, any electric current passing along the wire from a distant station would traverse this coil in its course, and would deflect the needle, and so make a signal. I should here mention that, for the sake of regularity, we adopt one unvaried order in attaching wires to the instrument; it is to put the up-wire on the terminal, shewn by U in the figure, the coils being all uniformly wound.

25. So far for receiving a signal; now for sending one. Were we to go out on the open railway, taking with us a battery (§ 7), and to cut any one of the wires, and place its two ends, thus obtained, upon the two terminal ends of the battery, a current would pass along the line, and the needles on that wire would be deflected; and if we changed hands so as to reverse the connections, the deflections of the needles would be reversed. The same would happen were we to cut a wire inside the office, or inside the telegraph, and to treat it in a similar way. Now, in every apparatus contrived for transmitting signals, we have a *place corresponding to such a cut wire;* and, near this place are the poles of the battery, mounted and movable, so that they may be readily applied in the breach, one way or the other as required. The place here (Fig. 3) is the top of the springs. They are not *joined* to the brass rod *n*; but, as I said before, *press hard* upon it, and can readily be raised with the finger, or otherwise. It is obvious that when either of them is raised the circuit is broken. Now near this place is a mechanical contrivance, by which the poles of the battery may make a breach in the circuit, and be applied in the breach in either direction. The drum B is of box-wood, the ends *c* and *z* being capped with brass,

and insulated from each other by the wood, *b*, left between them. The drum is movable by a handle, not in sight here, but visible in Fig. 15 (§ 104); and is supported as shewn in the present figure. A stout steel wire *c*′ is screwed beneath into the *c* end of the drum; and a similar wire *z*′ is screwed above into the *z* end. These two wires are the poles of the battery, *z*′ being connected with the zinc end, and *c*′ with the copper, thus:—from the copper end of the battery a wire is led to the terminal c; thence a slip of brass leads to a curved brass spring which presses closely on the drum at *c*; from the zinc end of the battery a wire goes to the terminal z, and thence a slip of brass leads to a similar curved spring, pressing on the continuation of the *z* end of the drum, as shewn in the figure. It will be seen that, whenever the drum is moved, the steel wire *z*′ will lift up one or other of the upright steel springs; it is now lifting up the right-hand one, and so breaks the circuit; but, by a little further motion of the drum, the wire *c*′ will press upon the boss below, as shewn in the figure, and thus there will be a battery-pole on each side of the breach, and a signal will be made on this, and on all instruments connected with it. And, from the peculiar arrangement of the drum, the motion can be changed as rapidly as the hand can move. I have shewn the battery connections exactly as they occur in practice; and the connections are such that if the right-hand spring is moved off, the needle moves to the right, and if the left to the left. The needle on the face of the instrument always has its north-end upward, and the needle within the coil its north-end downward, so that, by the law I have elsewhere stated (§ 11), if we look at the face of an instrument, and see the top end of the needle move to the right, we may be sure that in the half of the coil nearest to us the current is *ascending*.

26. THE ELECTRO-MAGNET.—We have seen how the mutual relation between voltaic *currents* and *magnetized* bodies is turned to account in producing signals, and we have now to examine the relation between voltaic *currents* and *magnetic* bodies,—that is, bodies not magnetized but *capable of acquiring magnetism*,—in order to understand the arrangements, of which we avail ourselves, for sounding alarums to gain the attention of the officers in charge of the telegraphs. Iron and steel are the most important magnetic bodies. Good iron will acquire on the instant extreme magnetization, and will also part with the whole, the moment the inducing cause is removed; steel acquires magnetism more slowly, but retains it after the inducing cause is removed.

If cotton-covered wire is coiled round a bar of steel or iron, and a voltaic current is transmitted through the wire, the bar becomes magnetized; the steel bar permanently; the iron bar *temporarily*, returning to its neutral condition when the current ceases; for which two properties it is admirably adapted to our purposes, as we shall soon see. Iron bars, under such circumstances, are termed *Electro-magnets*. By using stout wire and powerful batteries, electro-magnets of enormous power may be produced; while, by using fine wire many times wound round, a small electric force is repeated so often that it produces an effect, which otherwise would not be made manifest. The magnetic poles are reversed according as the direction of the current is changed. The rule is, that if, on looking at the end of the bar, the current is passing round as the hands of a watch move, that end will be a *south pole*. Although the *lifting* power of an electro-magnet may be great, its *attractive* power is comparatively small, and vanishes at a very short distance. Horseshoe or U-shaped magnets are the most powerful; and if, after having attracted a piece of iron which shall rest across both poles, the current is cut off, a considerable quantity of magnetism will remain, while the iron keeper is undisturbed; but vanishes when the iron is removed. The *amount* of magnetism is represented by the amount of electric force circulating around; and is the sum of the force circulating in each convolution of wire. So that an electro-magnet of 100 convolutions would be twice as powerful as one of 50, were there not some allowance to be made for the increased resistance of the longer length of wire, and the greater distance of the last than of the first convolution from the centre.

27. *Telegraph Electro-Magnet.*—From a rod of soft iron, half an inch in diameter, are cut off two 2-inch pieces; with these as cores, and an ivory or brass disc about an inch in diameter at each end, two bobbins are constructed, which are to be filled with silk-covered copper wire about $\frac{1}{130}$th in. in diameter. The bobbins are placed side by side, and connected into a horse-shoe or II-shaped magnet by a cross-piece of soft iron, as shewn in Fig. 7 (§ 49). The wire is connected into one continuous length, and the system becomes magnetized every time a current is transmitted along the wire; and returns to its normal condition when the current is cut off, by an arrangement to which we will now refer.

28. THE ALARUM.—Fig. 4 gives at A a side view of the electro-magnet just described: in front of it is a small soft iron keeper B, one inch in length by half an inch in width, of which we here see the edge. This keeper is attracted by the poles of the electro-magnet *every time* a current is made to circulate around it, and *as long* as it is in circulation; and attraction ceases the moment the current ceases. To prevent the keeper remaining attracted, as we have said, soft iron will often do, even

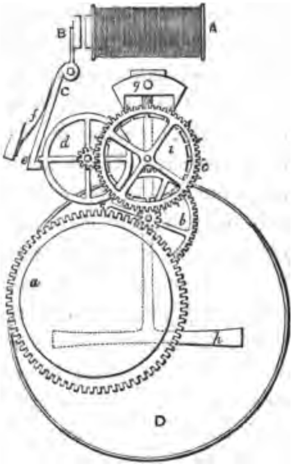


Fig. 4.

after the force ceases to circulate; we never allow it *actually to touch* the polar surfaces of the electro-magnet. For this purpose we prepare small brass screws and tip them with ivory, and insert two in two small holes drilled in the keeper, with the ivory tips just sufficiently protruding to prevent actual contact; while, at the same time, the keeper is allowed to approach very closely: the keeper is also so adjusted that, when in its state of rest, it shall be as near as convenient to the poles of the magnet; for the attractive power of electro-magnets is greatly reduced as the distance increases. The rest of the figure represents in correct outline the mechanism by which the bell is rung, but which is now in the position of rest. We will proceed to show how the electro-magnet acts in liberating it. The keeper B is mounted on the shorter arm of a lever C; the other end of the lever terminates in a hook or catch *e*, which catches a pin in the circumference of the wheel *d*, and prevents it moving: *f* is a slender reacting spring pressing against the long arm of the lever C, and by means of which the keeper is restored to its normal position when attraction ceases, and the catch *e* is made to act. The figure shews only such parts of the mechanism as are necessary to explain the general principle: *a* is the box containing a mainspring; *b* a toothed-wheel connected with *a* by a pinion; *c*, a toothed wheel having a pinion working in *b*; *d*, the wheel that carries the stop, and connected by its pinion with *c*; *g*, is an escapement, working in pallets on the wheel *i*, which is on the same axis with the wheel *c*; *h* is the bell hammer; it is virtually a short pendulum, its connections and action being quite similar. When the voltaic current is made to pass along the wire of the coils A, the soft iron cores are magnetized, and the keeper B is attracted; this raises the catch *e*, and so allows the wheel *d* to move. The machinery being thus liberated, the mainspring in the box *a*, which is kept wound up, sets it in motion, and the pendulum hammer *h* vibrates rapidly and strikes the bell D, which is shown also in section. When the magnetization ceases, with the cessation of the current, the catch *e* is pressed into its place again by the reacting spring *f*, and the ringing terminates. The force of the spring *f* may be modified by means of a small adjusting screw provided for the purpose.

29. It will be seen from this description, that the alarum is sounded by ordinary mechanism, and that the office of the voltaic force is merely to move a lever and liberate the machinery; whence it is obvious that there is little limit to the amount of noise we may produce; for we have merely to liberate *powerful* machinery, in order to strike *hard* blows on a *loud* bell; and hence, for special purposes, we are provided with large sonorous alarums that are to us the "Great Toms" among telegraph bells.

30. There are some half dozen modifications of this principle; for example, we have hammers still pendulum fashion outside the bell, and beating only in one of their motions; we have the catch *e* made pointed, and falling into a little hole in the *face* of a wheel corresponding to

d; we have some keepers moving as a door moves, and carried by pivots, and liberating another form of catch; then, again, there is Mr. Wheatstone's *centrifugal bell*, where instead of a pendulum, the hammers, for there are two, are at the ends of an arm fixed to the axis of one of the quick-moving wheels, and they fly round, giving famous blows to the bell as they pass. In these last alarums the check is a strong notched spring, catching and retaining the arm that carries the hammer: when the keeper is attracted, a weighted lever is set free, and in falling knocks away the strong spring, and releases the striking arm. Whichever mechanical arrangement is adopted, the electro-magnet attracting a keeper is the means of liberating it. It remains therefore for us to see how the current is sent through the electro-magnet, and how arrested at pleasure.

31. *Bell-handle, or Short Circuit.*—In certain cases we employ a distinct wire for the bell, and a special mechanism for transmitting the current: the description of this mechanism, or *ringing-key* as it is termed, will come in more profitably, and will be better understood by-and-bye, (§ 43.) We pass on to the case in which the bell-coil, or electro-magnet, is on the same wire, or in the same circuit with the needle-coil or galvanometer. In this case, every current that passes through one would pass through the other; and after the bell had served its purpose of gaining attention, the clerk would be annoyed by its ringing, while he was reading the signals of the needle. This is prevented by what is termed *joining over*, or making the *short circuit;* in fact, by providing for the current a shorter and much more capacious road to the galvanometer than by going through the fine coil of the electro-magnet. If things were so arranged that the current should have to pass up the left limb of a wire bent like the letter ʌ to an

electro-magnet on its apex, and then down the right limb, to go onward to the galvanometer, it is obvious that the alarum must ring whenever the force circulates; but if a piece of metal were placed crosswise, as in the letter A, the current need not traverse the apex, and pass the electro-magnet to pursue its course; in practice it divides, and as the cross-piece is *short* and *stout*, and the bell-coil *long* and *fine*, the greater portion pursues the former path, and so small a portion traverses the latter, that it has no power to make the electro-magnet act. We make this *short circuit* by turning a brass-handle, shown on the left side of Fig. 14 (§ 90). The bell is in the box above the instruments; the two brass slips, shown on the left of the bell box, are connected with either side of the coil. The back one conveys the current up to the bell-coil, and the front one leads it down to one of the needle-coils. They are continued downwards inside the instrument; the brass *handle* is connected with the front one; the brass *spring*, beside the handle, is connected with the back one:—a lump of ivory is inserted through the handle. As it now stands vertically, the spring presses on the ivory (which will not conduct electricity), and the current cannot pass without going up one wire and down the other, and, by so doing, through the bell-coil; but if the handle is turned into a horizontal position, the spring presses upon the metal of the handle, the short circuit is made, and almost all the force travels by that path, and little force through the bell-coil.

32. TELEGRAPH WIRES.—Had the wire W (Fig. 3, § 23), been a loop of many yards in length, and been cut in the distance; and the part proceeding from the terminal U were connected with a terminal D of an exactly similar instrument, and the wire from the terminal D were connected with the terminal U of this similar instrument, it is obvious

that any current made to pass from the battery would circulate in both instruments, and produce similar deflections of the needle in each. What is here done in the same apartment on the small scale is to be done on the large scale for instruments many miles apart. We have, therefore, to show the mode of suspending the wires, and the precautions that are taken to prevent the force being lost in its transit, or misapplied.

33.—The wires for the *open line* are No. 8 *galvanized iron*, which is about $\frac{1}{6}$th in. in diameter. The wire has been passed through a bath of melted zinc, or, as it is termed, *galvanized*. The iron becomes coated with zinc; and its zinc surface, now combining with the oxygen of the atmosphere, forms a coat of oxide of zinc, which effectually protects the wire against further corrosion, and it is thus made very durable. They are supported on wooden poles or standards, varying from 14 or 16 to 28 or 30 feet in height. The lower wire is 8 or 10 feet from the ground, unless required higher over sidings or level crossings, &c. The poles are from 6 to 8 in. square at bottom, and from 5 to 6 in. at top. They are painted white, and are charred and tarred where they enter the ground: there are thirty or thirty-two to the mile. Were the wires simply secured to the wood itself of the poles, the force would, to say the least, pass from wire to wire in all wet or damp weather—for voltaic currents will *traverse water* by decomposing it, and the signal would not arrive at its destination.

34. *Insulators.*—To guard against this, some better non-conducting material must intervene between the wire and the wood. Common brown stone-earthenware is found to be famously adapted to the purpose. If we take a brown stone-pitcher and dip it into water, it will come out in a general way dry, with only a few drops of water hanging here and there; in like manner, the earthen insulators employed

between the wire and the wood greatly repel the wet, and secure to us insulation. They are made in the form of rings, double cones, tubes, collars, &c., according to the circumstances under which they are to be applied. Fig. 5 shows several of the line contrivances. On the left is the head of a *pole*, the office of which is to *sustain the wires*. On its front is a wooden *arm;* between the arm and the pole are earthenware *rings*. An iron bolt, passing through the arm, the ring, and the pole, and through another ring and arm on the other side, where it is tightened by a nut, secures the arm. On the front of the arm may be seen four earthen cones; they are secured by large iron staples or *clips*, and through the cones the wires pass, one through each. To prevent confusion, I have omitted an equal number of wires, passing in an exactly similar manner, at the back of the pole.

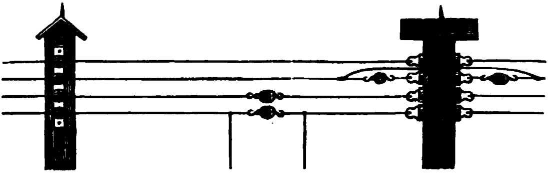


FIG. 5.

35. *Winding Posts.*—On the right is the head of a *winding post*, of stouter timber, to which the wires are *strained and tightened*. An iron bolt passes through the post, but clear of the wood, having at each end a winder, as shown in the figure, consisting of a grooved drum, with a wheel and ratchet attached. The winder heads are kept away from the post by earthen collars, through which the bolt passes. The winder and bolt, being of galvanized iron, constitute a continuation of the metal circuit, and the current passes on through them, as shown in the upper wire. But as the joints of the winder may corrode or form *bad*

contacts, and as dust may accumulate round the collars and form a receptacle for water, it has been found better to use the winder merely *as* a winder; to insulate it altogether from the wire; and to provide a side path to take the current onward from one side of the post to the other. This plan is shewn in the second wire. The pulley-like appendage, or, as we call it, *shackle*, consists of an earthen ring, furnished with two hooks; the connections of one of which pass *round* the ring, and those of the other *through* its centre, so that the hooks are effectually insulated from each other, and no current can pass from one to the other. The wire is cut, and the shackles are inserted one on each side of the post, so that the post is now doubly cut out of the circuit. A thin wire is then soldered over from the outside of each shackle, and along this wire the current can pass. The posts are placed at every quarter of a mile: half the number of wires are wound at each post, and the other half pass on to the next, being sustained on this post, as they pass, by an arm at the back. Each wire, therefore, is wound in half-mile lengths. The lengths are made up of pieces of wire looped and bolted together, with a short wire soldered over the joint. Similar apparatus is used at bridges and tunnels; but is supported by the masonry, instead of by standard poles. The points, visible above, are connected with the earth by a wire to protect the poles from lightning.

36.—On the back cover of the book, I have illustrated the general appearance of the telegraph poles on a railway, by giving a sketch of the spot where the Tunbridge Wells branch joins the main line. It shows the switchman's cottage, and the box opposite, with the manner in which the wire crosses the line and enters it. Of the five wires shown, the upper two go through from London to Dover, and the others from Tonbridge to Maidstone. The relative positions of these places will be seen on the map (Fig. 9), and on the plan (Fig. 10, § 53).

37. *Bringing in the Wires.*—In the centre of Fig. 5, I have shown the contrivance by which wires are led into a station, so that an instrument may be introduced into the circuit. The third wire is cut, and a *shackle* is introduced; in this case the circuit is broken, and the force could not pass from the wire on one side of the shackle to that on the other. But if two pieces of wire are attached, one on each side of the shackle, as I have shown in the fourth wire, and these wires are continued, each through an earthen collar, into a telegraph office, and one of these is attached to the terminal U, and the other to the terminal D, of the instrument in Fig. 3 (§ 23), the current will be able to get from one side of the shackle to the other, by passing through the galvanometer coil. This is exactly the plan, by which telegraph stations are connected up; and just as we have here introduced one instrument, we might in other parts of the wire introduce others.

On the front cover, I have given a view of Tonbridge station, showing the outside of the telegraph-office, and the manner in which the wires pass on at a station. They are held up by *suspension pieces*, carrying earthen rings, of which the first two are shown. Shackles are introduced into all the wires as they pass the window, and thin wires are led into the office (as will be better seen in Fig. 11, § 59) from *one* side of the shackle for a terminating series, and from *both* sides for a continuing series. The two wires from the office crossing the line on the edge of the bridge are continued under the Hastings road to my instrument.

38. *Street Wires.*—For conveying wire beneath the high road and the streets of towns, other precautions are required. The wires for this purpose are No. 16 copper. They are first covered with cotton saturated with tar,

and are then drawn, in clusters of three, four, or more, through small leaden pipes. The leaden pipes are secured by being surrounded with tarred rope, and are buried in the ground in iron tubes. At certain intervals the ends of the various wires are brought up above the surface withinside an iron post, where they are connected over. This is a "testing-post," and is used for examining the state of the respective wires. Wires are conveyed in this way from the Telegraph Company's central office in Lothbury, at the back of the Bank of England, to the Admiralty, Whitehall; to a telegraph office, West Strand; to the termini of the South-Western, the North-Western, and the Eastern Counties Railways, at Waterloo Bridge-road, at Euston-square, and at Shoreditch, respectively. Wires, better and more extensively protected, have lately been laid down between Lothbury and the General Post-office, in St. Martin's-le-Grand.

39. *Gutta-Percha Wires.*—Bare wire was formerly employed in tunnels, as on the open line (§ 33); but in tunnels water percolates abundantly, dust from the engines and fumes from combustion accumulate, the earthen insulators become much defiled, and the insulation is greatly deteriorated, so that a current intended to go (say from Dover to London) along wire 1 finds its way partly over the wet dirt to wire 2, so that a portion only goes on to London by wire 1, a lesser portion by wire 2, and a considerable portion returns to Dover by wire 2, while some is lost altogether, producing of course great confusion and no little inconvenience.

40. The tunnels on the South-Eastern Railway gave me much trouble, and, in self-defence, I was compelled to look for a remedy; and was led to take a very prominent part in promoting the manufacture of a wire covered with gutta-percha. It has been accomplished by Mr. Forster

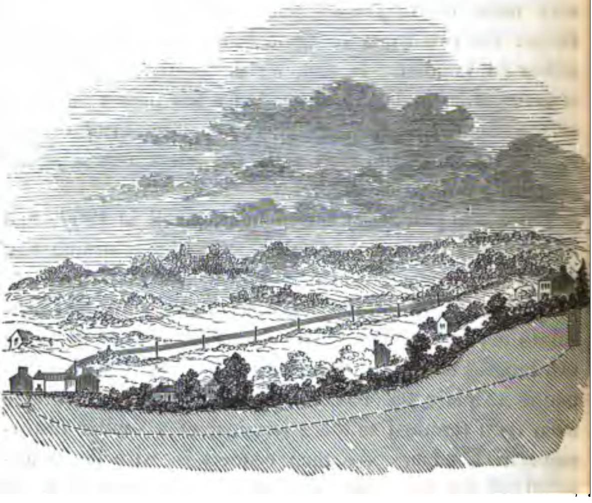
in the following manner:—The gum, after being cleaned, is macerated by steam machinery in a heated iron vessel; it is thence transferred, lump by lump, to a pair of heated grooved rollers, between which it is passed, and is pressed into solid cylinders three or four feet long. It is now ready for the *covering-machine*, to which it is carried, and where it is used while warm and soft. This machine consists of two pair of hollow polished-iron flatting-rollers, heated, as occasion requires, by steam, and of a pair of small grooved cutting-rollers. The cutting-rollers vary, both in the number and the size of the grooves, according to the character of covering required. The wire employed in our tunnels is No. 16 copper, and is covered by six-grooved rollers, six wires being covered at one operation, the diameter of the wire with its covering being ¼ inch. The two pairs of flatting-rollers are one over the other, with a small interval between; two of the solid cylinders of gutta percha are passed one between each pair, and appear on the other side as soft flattened sheets; the six wires traverse the interval between the two pairs of flatting-rollers, and pass between the six-grooved cutting-rollers, with one of the sheets of gutta percha above them, and the other below; and they appear, on the other side, as a perfect band of six covered wires: they are pulled apart when single wires are required, or left undisturbed when required in a band. I have substituted this wire for the ordinary bare wire, for the important wires in all wet tunnels; and have accomplished telegraphic feats under these circumstances which could not have been attempted on the old plan. It has stood a long and trying test. I have no doubt it will be used for street wires in future work.

41. THE EARTH CIRCUIT.—We have in the very outset (§ 5) shewn that a closed circuit is an element essential

to the very existence of voltaic force; we have shewn, more specially when describing the connections of a telegraph instrument (Fig. 3, § 23), that a wire starting from the terminal U must ultimately return to the terminal D, and constitute a closed circuit before the signals can pass. Following out this idea, it would seem that if the instrument (Fig. 3) were fitted up at Dover, and a wire proceeded from the terminal U *to* London, another wire must return *from* London to the terminal D at Dover, the two wires being in some way connected together at London. In fact, we should have a wire loop of many miles in length, instead of a few inches as shewn in the figure; and, in practice, for each series of galvanometers we should need a *pair of wires,* one being the *returning half* to the other.

But it was practically shewn by Steinheil in 1837, and subsequently confirmed by others, that the returning half of the wire might be dispensed with, and that the *earth itself* would perform the function of this wire, and constitute one-half of the circuit; so that, instead of using two lengths of wire as described above, our plan in practice is to place the instrument at Dover, and take a wire from its U terminal to the D terminal of a similar instrument in London. We then connect by wire the D terminal of the Dover instrument with the gas and water pipes of Dover, and the U terminal of the London instrument with the gas and water pipes of London, and we thus obtain not only a perfect but a better circuit; namely, one presenting *less resistance* than if we had used a return wire, and we *save,* consequently, *one-half* in the cost of wire, and obtain better results. When there are no pipes, we dig till we reach moist earth, and bury there a plate of copper, from which a wire proceeds to the telegraph-office. The sketch (Fig. 6) will illustrate this. In the cottage to the right is a telegraph instrument, to which there is a corresponding instrument in the telegraph-office to the left. The line-wires pursue some such course as I have here represented, arriving at their destination by wires laid under the turnpike-road; and they connect the D side of one galvanometer with the U side of the other.

Fig. 6.



The remaining sides of the respective galvanometers are connected with the earth, in the one case by a wire soldered to a buried copperplate, and in the other by a wire passing into the well by means of the pump. The dotted line in the section of the soil shews the *direction* in which the earth completes the circuit. Every telegraph station is provided with an *earth-wire;* that, in addition to its ordinary duties (of which more hereafter), enables us to cut short any part of the line, and test for faults.

42. The most remarkable feature of the earth circuit is, that it appears to present no resistance to the circulation of the force; whereas metal wires, the *best* of all conductors, each and all present a *very sensible* resistance; if the earth were a *solid mass of metal* it could not act more perfectly. For example: ten wires enter the London office (see Fig. 10. § 52), each going to one side of a galvanometer. The other sides of the galvanometers are *connected* respectively by ten wires with a long *slip of brass*, which brass is connected with the water-pipes; so that, in point of fact, the wires, notwithstanding all our care and cost (§ 34) to keep them insulated from each other throughout their course along the railway, are actually *one and all clustered together*, and *connected* into one common bundle, as soon as they have passed the galvanometer. The dotted continuation of the wires marked E, at Ramsgate, Deal, and Dover (Fig. 10, § 52), may be referred to in illustration.

43. Notwithstanding this *oneness* of the wires, providing all is clear along the line, a current can be sent along any one of the ten without any portion being distributed among the other nine; and thus we are presented with the very extraordinary phenomenon of metal wire—one of the best conductors of electricity—acting as a perfect insulator, or non-conductor. This is the more striking the more closely we look into the conditions of the phenomenon. Take the case of two wires only as an example: they are *united*, and are joined to the earth-wire before they enter the London instrument. They are kept carefully apart from London to Dover; but after passing the Dover instrument they are again *united*, and are joined to the earth-wire, so that they form a *continuous loop*; and yet the current intended for one wire always takes the earth as the *return half* of the circuit, and no part of

it finds its way into the companion wire. But if by any accident the earth-wire is divided, the case is widely altered; and the current tells its own tale by its reverse action on the other galvanometer, for it now accepts the companion wire, which before it entirely rejected.

44. This *perfect* action of the earth circuit has been commonly attributed to *bonâ fide* conductibility. Its notoriously inferior conducting properties, as compared with metal wire, are considered to be more than counterbalanced by its enormous mass. For instance, in the sketch (Fig. 6) the sectional area of the earthy mass is thought to be so great in respect to the sectional area of the one-sixth inch companion wire, that the conductibility of the latter is said to be as zero in the comparison.

45. Let us follow out this idea, and assume for the earth a maximum conducting power equal to that of salt water, which is an extreme standard. Now, iron wire, according to Cavendish (quoted by Brande, in his *Chemistry*), conducts electricity 4,000,000 times better than sea-water. Our iron wire is $\frac{1}{6}$th in. in diameter; the conducting power of bodies is as the area of their section. From these data, a simple calculation* shews that about 28 feet would be the diameter of a cylindrical section of the mass of earth, equivalent in conducting power to one of the telegraph wires. If, therefore, a $\frac{1}{6}$ in. companion wire and such a section of the earth were presented jointly, as in practice they are, as paths to a voltaic current, exactly *one-half* would go by each course. But in the case before us *none whatever* goes by the companion wire, so that in order to act as a conductor, a mass of earth to all appearance *indefinitely larger* than this must be called into requisition. If there were a *little* trace of cur-

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* $\sqrt{4000000 \times \frac{1^2}{6}}$ in. $= 27.77$ ft.

rent in the companion wire, we might draw comparisons; if there were $\frac{1}{100}$th, or $\frac{1}{500}$th, we might say the earthy cylinder was 277 ft. or 613 ft. in diameter; but this is not the case. Nay, more; in the London station *nine* companion wires have been mentioned. This would compel us to multiply the above high figures by $\sqrt{9}$ or 3; and we should have 831 or 1,839 ft. Furthermore, *eight* of these companion wires are many miles *shorter* than the wire under consideration; they, therefore, conduct *better*, and we must again increase our figures.

46. Nor is this the climax of the difficulties by which this view of the action of the earth is encumbered. The *solid* materials of the earth are but poor conductors; to the fluids, therefore, must we resort for aid, and to the compound bodies they hold in solution. But Faraday has taught us, that "without *decomposition* transmission of electricity does not occur" (*Researches*, § 855); so that the wetness or liquid of an enormous cylinder of earth, not less than 2,000 ft. in diameter, and extending 88 miles, must suffer decomposition, and give off hydrogen gas at London and oxygen at Dover, in order that the earth may act as a conductor, and form the returning half of the circuit between these two towns.

47. *The Earth a Reservoir of Electricity.*—For myself, I have long seen the confusion in which this question involves us, and have been unable to admit the existence of actions so extensive as those to which we have been led by the above inquiries; and we are thus reduced to the only other alternative of *rejecting* altogether the idea of *conduction*, as far as the earth is concerned, and of regarding the globe merely as a vast *reservoir* of electricity. We know that if a cloud has too much *positive*, or too much *negative* electricity, *no matter which*, a flash of lightning soon sets matters right by darting to the earth, and so re-

storing equilibrium. In like manner, the charged conductor of an electrical machine, *whether the positive or the negative*, is instantly discharged and restored to its normal state by communication with the earth. In like manner, if the pole of a voltaic battery is connected with the earth, a certain discharge occurs. Take, for instance, Mr. Gassiot's experiment. He insulated a voltaic combination by glass pillars on an Arnott's stove. "If, in this state, one of the poles is touched by the hand, its electric tension is apparently destroyed, the leaves of the electroscope in connection collapsing, whilst those of an electroscope attached to the other terminal obtain their extreme divergence. . . Generally, the means of raising the tension of one extremity of the battery is to touch the other."—*Phil. Trans.* 1844. Part I. p. 46. In our case, *both* ends of the battery are connected with the earth—one at London and the other, by the long-conducting wire, at Dover. And it would seem that they are respectively neutralized, one by positive and the other by negative electricity obtained from the earth, or, to use the other form of expression, the positive end of the battery gives off positive electricity to the earth at London, and the negative end gives off negative electricity by means of the telegraph wire to Dover, or *vice versâ*.

48. The improbability of the old idea of the earth's conduction is more than confirmed by recent experiments made by M. Breguet with the telegraph wires on the line of railway between Paris and Rouen. They are described by the Abbé Moigno, in p. 210 of his *Télégraphie Electrique*, lately published in Paris. The French philosopher constructed two sine-galvanometers (§ 16), as nearly similar as was possible, and which were very uniform in their action; for measuring, at the same time, the value of the forces at the two stations respectively. He passed

currents between Paris and Rouen; in the one case by a circuit *all wire*, and in the other by a circuit *half wire and half earth*. By substituting the earth-circuit for the return wire, he always reduced the resistance *one-half;* in other words, a circuit of forty miles of wire, and another circuit of forty miles wire and forty miles earth, presented the same resistance, and gave the same results; the earth presenting *no resistance at all;* and if so, not acting as a conductor. The Abbé considers the earth to act as "a reservoir, or drain, in the which positive electricity on the one hand, and negative electricity on the other, are lost or absorbed." Gauss, of Göttingen, holds a similar opinion; he regards the earth as absorbing, or *drinking up*, the electricity. The question, however, still remains an open one. But it matters little to us here how the earth acts in causing the transfer of the force, so long as we understand the practical *effect* of the earth-wire. Understanding this, we are able to proceed with our description.

49. *Ringing Keys*, — employed for transmitting a current along a wire devoted only to alarums, were passed by in the earlier stage of our inquiries (§ 31), as it required a knowledge of the earth-circuit in order to understand their action. We may now describe, first, the simpler form; and, secondly, the improved form. The one sends a current along the whole wire, from *end to end;* the other sends the current from the *ringing station* to *either* end of the wire. Fig. 7 is a sectional view of the first of these, showing also its connection with the electro-magnet of the alarum (Fig. 4, § 28); I have omitted all fittings and supports. A is a small brass drum, ¾ in. in diameter and the same in length, pierced in the direction of its length, and about half-way through, by two holes, *f* and *g*, which are then plugged with ivory. On its sides, and at right angles

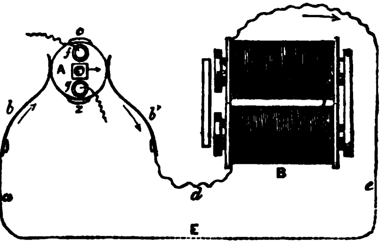


Fig. 7.

respectively to the holes *f* and *g*, and meeting them, are drilled two holes at *c* and *z*, which are likewise plugged with ivory. The ivory plugs *c* and *f* are drilled so that the holes meet, care being taken not to expose the metal; a stiff brass wire is driven in at *f*, and a brass screw is screwed down at *c* to meet it, and make close contact. The same is done at *z* and *g*. A loose coil of wire is attached to *f*, and another to *g*, connected respectively with the copper and zinc ends of the battery. The screw-heads *c* and *z* represent, therefore, the battery-poles, perfectly insulated from the surrounding materials.

The ringing key is represented in a state of rest;—and, as A is of brass; *b′* a steel spring; *d*, a copper wire leading to the electro-magnet; B, the copper wire coils; *e*, a line wire going, for instance, to Ramsgate, if this apparatus were at Canterbury (see Fig. 10, § 52); E, the earth-circuit between Ramsgate and Ashford; *a*, the line wire from Ashford to Canterbury; and *b*, another steel spring; there is a complete circuit; so that if a current is sent into the wire from any other part of the circuit, it will pass through this apparatus, and, acting on this electro-magnet, will cause the alarum to sound.

To use this apparatus, and cause it to send a current from end to end along the line, we turn the drum one-quarter round, which causes the stud *c* to press upon the spring *b′*, and the stud *z* upon the spring *b*; that is, we break the circuit, and put the battery poles in the breach

(§ 25), which causes a current to pass in the direction of the arrows from end to end along the line, ringing all the bells. The apparatus is provided with a strong self-acting spring, to restore the drum to its natural position when the hand is removed.

50. But, with this key, it is obvious that if the Canterbury clerk wished to call the attention of Ramsgate, he would ring the Ashford bell also, which answers no good purpose, and employs the force to the least advantage. On this account, I have contrived the ringing-key, (Fig. 8), that sends the current *either* up or down the line, as occasion requires; and by ringing the bells in one direction only, economises the force. I have provided all intermediate stations with it, and with great success and much advantage.

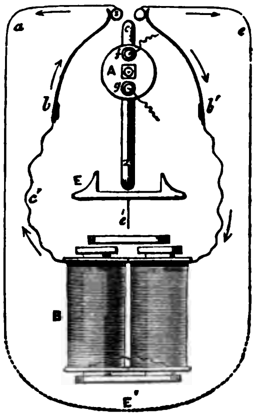


Fig. 8.

Considering this ringing-key to be at Canterbury, where, indeed, there is one such, *a* is the *up*-line wire, leading from Canterbury to Ashford, from a brass stud *s*; *e* is the *down*-line wire, leading from Canterbury to Ramsgate, from a stud similar to *s*; the dotted line E′ is the earth circuit between Ashford and Ramsgate; *b* and *b′* are two strong steel springs, pressing hard on the studs *s*; the springs *b b′* are respectively connected with either side of the electro-magnet B by wires *c′*. Thus far there is a complete circuit, so that any other station can send a current, say, in the direction of the arrows, and cause the Canterbury alarum to ring. The drum A is of brass, as before, and similarly pierced, and plugged with ivory at *f* and *c*, and at *g* and *z*; but, in place of mere studs, is provided with a short stout wire *c*, and a longer one *z*. E is a solid brass stud, from which a wire *'e* is led into the earth at Canterbury. If now the drum is rotated a little in one direction, the bells *up* the line are rung; if in the other direction, the bells *down* the line. We will describe the former case.

By moving the drum, the short wire *c* lifts the spring *b'* off its stud; and by continuing the motion, the wire *z* touches the earth-connection at E. We thus, as in all similar operations (§ 25 and 49), begin by breaking the circuit, and end by putting the battery poles *c* and *z* in the breach. The current now coming from the copper end of the battery by the wire *f*, and being kept clear of the drum by the ivory, issues at *c* to the spring *b'*; it passes in the direction of the arrow through the electro-magnet B; and by the wire *c'* ascends the spring *b* to the stud *s*; it goes thence by the wire *a* to Ashford, where it enters the earth; and thence the circuit is completed to E by the wire *e'* leading from the earth; and at E' it finds *z* the other pole of the battery. In this case, the wire *e*, leading to Ramsgate, is not included in the circuit; and the current only traversed the line in *one* direction. Had the handle been moved in the reverse direction, the current would have passed down the line, and the bells up the line would have been undisturbed. A self-acting spring restores the drum to its vertical position.

51. A SYSTEM OF TELEGRAPHS.—Having had a tolerable view of the several parts in detail of a line of telegraph, we are prepared to study more closely the manner in which they are combined into a general system. The South-Eastern Railway Company possess what may be very well termed a *self-contained* system of telegraphs.

They are complete in themselves, and are unassociated, either electrically or commercially, with any other series: they will serve as our illustration. They extend from London to Rochester, and from London to Dover, with branches to the Kent Road, to Tunbridge Wells, to Maidstone, and to Ramsgate, Deal, and Margate, their total length being about 182 miles. Fig. 9 is a map of the district, shewing the geographical position of the several telegraph stations, and the parts of the railway itself. Belonging to the same Company is a line of railway, 46 miles, from Reigate to Reading, on which the telegraph is not yet erected; and lines of railways not quite completed, from Tunbridge Wells to Hastings, and from Ashford to Rye, near Hastings.

Fig. 10 is a plan, shewing the arrangement of the telegraph apparatus in this district. The lines ≣ represent the wires, numbered in practice, 1, 2, 3, 4, &c., for reference; the half-dots ◓ are for the alarums, and the dots • for the galvanometers; the *single* dots are single-needle instruments (Fig. 3, § 23, and Fig. 15, § 104), and the dots *encircled in pairs* ⊙ double-needle (Fig. 14, § 90) instruments.

52. The stations are arranged in groups of not more than six or seven to a group. The lines in the plan are made *continuous* from end to end of a group: where the lines terminate, or are divided, the group terminates. Our most important group is from London to Dover, on the wires marked 1 and 2; these wires are seen to pass by all inferior stations, and to be provided with instruments only at the important stations of Tonbridge, Ashford, and Folkstone, in addition to the terminal stations. As they pass these stations, they have shackles inserted: and wires are led in to the instruments from each side of the shackle, as explained elsewhere (§ 37). To make provision for the

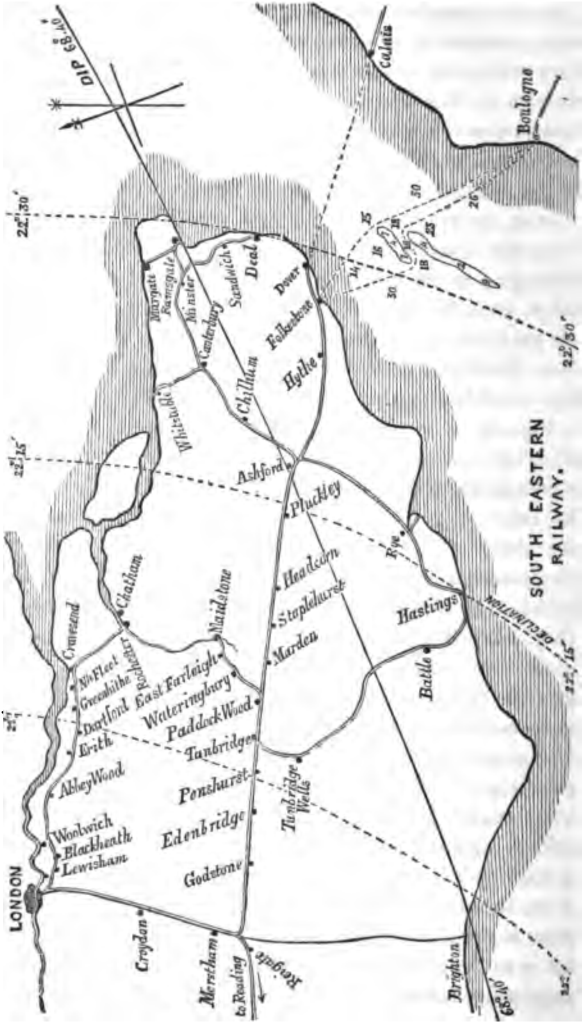

DIP 68.40
Calais
Boulogne
22°.30'
22°.15'
22°
SOUTH EASTERN RAILWAY.
DECLINATION
65.40
Margate
Ramsgate
Minster
Sandwich
Deal
Dover
Folkestone
Canterbury
Hythe
Chilham
Whitstable
Ashford
Pluckley
Rye
Headcorn
Staplehurst
Marden
Hastings
Battle
Chatham
Maidstone
Gravesend
Nth Fleet
Greenhithe
Dartford
Rochester
East Farleigh
Wateringbury
Paddock Wood
Erith
Tunbridge
Tunbridge Wells
Abbey Wood
Penshurst
Edenbridge
Woolwich
Blackheath
Lewisham
Godstone
LONDON
Croydon
Merstham
to Reading
Reigate
Brighton
14
15
16
18
23
25
26
30
50

FIG. 9.

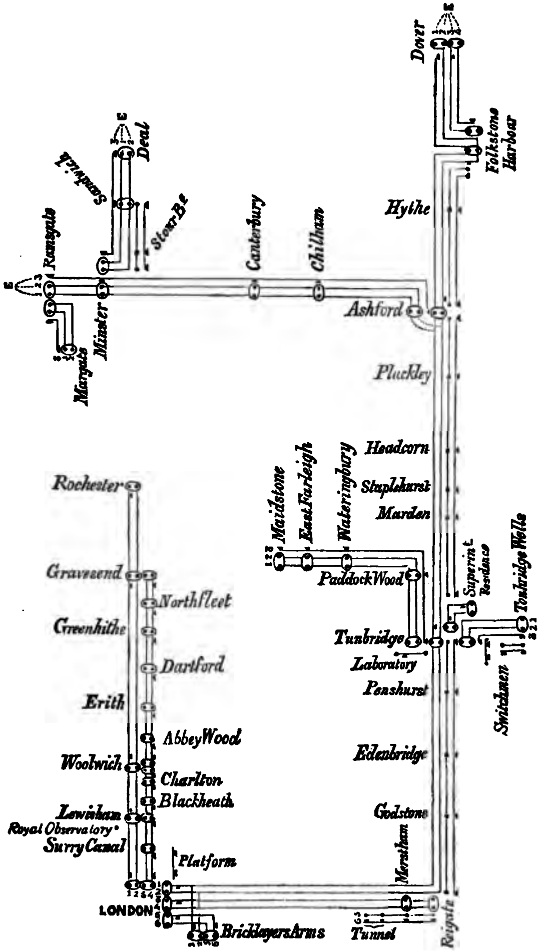

Dover
E
Folkstone Harbour
Hythe
Deal
E
Sandwich
Stour Br
Ramsgate
E
Minster
Margate
Canterbury
Chilham
Ashford
Pluckley
Headcorn
Staplehurst
Marden
Maidstone
East Farleigh
Wateringbury
Paddock Wood
Superint. Residence
Tonbridge Wells
Tunbridge
Laboratory
Penshurst
Switchmen
Edenbridge
Godstone
Merstham
Reigate
Tunnel
Bricklayers Arms
LONDON
Platform
Rochester
Gravesend
Northfleet
Greenhithe
Dartford
Erith
Abbey Wood
Woolwich
Charlton
Blackheath
Lewisham
Royal Observatory
Surry Canal

FIG. 10.

smaller stations, a second pair of wires, numbered 3 and 4, go from end to end of the line; these wires, however, are cut and made to terminate at Reigate, Tonbridge, Ashford, and Folkstone, so as to form five shorter groups of 3, 5, 6, 3 and 2, stations respectively. The series between Dover and London consists of five *double-needle* instruments; and the bell is on one or other of the wires, as shewn in the plan. The short groups consist, some, in like manner, of double-needle instruments, having the bell on one or other of the two wires; and others of single-needle instruments occupying one of the wires, and alarums occupying the other. London to Reigate, including Merstham, have *three* double-needle instruments; Dover to Folkstone, *two*: Reigate to Tonbridge, including intermediate stations, have *five* single-needle instruments on wire 3, and five alarums on wire 4; the like is the case for the *six* stations from Paddock Wood to Ashford, inclusive; and for the *three* from Ashford to Folkstone inclusive. A third pair of wires, making six in all, may be seen from Reigate to the tunnel beyond Merstham. And from London a pair goes to Bricklayers' Arms stations, and two pairs to Gravesend and Rochester, making *ten* in all entering the London station. It is obvious, therefore, that the number of wires that may be seen on a railway does not imply, as hundreds of people imagine, that the telegraphs of England require several wires to work them; but rather that there is a very extensive system, and a large number of stations to be supplied. As far as the telegraph itself is concerned, we might have used but two wires between London and Dover, or even but one; and have led these wires into every station. We should thus, however, have crowded the wires with a group of eighteen stations; and, as no two pair of stations could use the same part of the wires at the same time, the communications between Dover and London would be perpetually interrupted; and they, on their part, would interrupt others. And then, although all stations would be nominally *telegraph* stations, they would virtually be quite the reverse; for there would be constant waiting and confusion, and interruption.

53. The *North Kent Line*, from London to Rochester, has, in like manner, a through group of *five* chief stations on one pair of wires; and two shorter groups, of *six* and *seven* stations respectively, on a second pair. They are all double-needle instruments, with alarums on one of the needle wires. The branches to Tunbridge Wells, to Maidstone, to Ramsgate, to Deal, and to Margate, have each a pair of wires for double-needle instruments at the stations marked on the plan, and a third wire for the alarum. At Tonbridge, the switchmen (§ 36) have single-needle instruments and alarums on *one and the same* wire; at Tunbridge Wells they have instruments on one wire, and alarums on a second. We have thus illustrations of several methods of combining the apparatus.

54. I have said (§ 41) that all stations are furnished with an earth-wire. I have also shewn how all groups must terminate in the earth; and hence the use of the earth-wire at Margate, Ramsgate, Deal, Dover, Maidstone, Tunbridge Wells, London, Rochester, &c. &c. is obvious. And, when describing the ringing-key (§ 50), I shewed the application of the earth-wire in enabling us to sound the alarums in either required direction.

55. *Silent Apparatus.*—There is a third application of the earth-wire, of which we avail ourselves at Tonbridge, Ashford, and Folkstone, on the main line; and at Lewisham, Woolwich, and Gravesend, on the North Kent line. Take Tonbridge for an example:—We have represented wires 1 and 2 pursuing an uninterrupted course from London to Dover, and including the Tonbridge instrument in their course: hence, if London makes a signal for

Dover, or Dover for London, it must, of course, be visible at Tonbridge; and if Tonbridge makes a signal for London, it must be seen at Dover; because the circuit begins with the London earth-plate, and is continued by the unbroken wire to the Dover earth-plate; and, although not required at Dover, the current in this case must go there to get to the earth and complete the circuit. But if we provide it with a means of getting to the earth at Tonbridge, we shall save it this long and unnecessary journey, and it will at once enter the earth at the nearest spot: if, therefore, when talking from Tonbridge with London, we lead from the Tonbridge earth two small wires to the line-wires on the Dover side of the Tonbridge instrument, we cut the line short, and compel our signals to go only in the direction we require; namely, *up* toward London: by putting the earth-wire on the other side of the Tonbridge instrument, we pass our signals *down* the line only. A little arrangement, called by us *The Silent Apparatus*, is provided for performing this operation readily. Its face is seen at the lower part of the instrument (Fig. 14, § 90), with an index, showing its position for either operation. Four springs, two from the wires on the London side of the instrument, and two from those on the Dover side, are resting on a box-wood cylinder, ready for use. A slip of brass in connection with the earth-wire is inlaid in the wood; and by turning the cylinder in one direction the slip of brass is brought into contact with the springs on the London side, and by turning it in the other, with those on the Dover side; thus connecting the up or the down wires respectively with the earth. This operation possesses a double advantage: by reducing the distance one-half, it enables us to work with less battery power; and by confining our signals to one-half of the wires, it leaves the other half at liberty to other stations; and so, while

Tonbridge talks to London, Ashford may talk on the continuation of the same wires to Dover. The name of this apparatus is derived from another adjustment with which it is provided: by pointing the index to the word "silent," we move a brass slip into metal connection with the springs from either side of one of the galvanometers, and another brass slip with those of the other galvanometer; we then make a *short circuit*, and cause our *own* signals to appear on our *own* instrument only, and allow signals to pass on between other stations without entering our instrument; in fact, just as if the wires did not enter the Tonbridge station at all. The silent apparatus on the North Kent line is the same in principle, but different in construction.

56. By the above arrangement all the line is provided with instruments, and no part is overcrowded; and an examination of the plan will show that when a station *is not* in direct communication with a group it can hand its message on to a station that *is;* for instance, London gets a message to Penshurst by forwarding it *viâ* either Reigate or Tonbridge.

57. *Turn-plates.*—Under common circumstances the branch lines of telegraphs terminate at the junction stations,—as the Deal branch at Minster, the Ramsgate at Ashford, the Maidstone at Tonbridge, the North Kent at London. But there are contrivances for turning on the branch wires at pleasure to the wires of the main line, somewhat as trains are turned by switches from one line of rails to another. The *turn-plate* I have contrived is a cylinder of box-wood, inlaid with certain slips of brass, and mounted for protection withinside a small mahogany box; a series of steel-springs press on either side of the cylinder, and are connected with terminals on the outside of the box; the wires are connected to these terminals.

The slips of brass are so arranged that in one position of the cylinder the springs are connected into *one set* of pairs of springs, and by giving it a quarter revolution they become connected into *another set* of pairs. We shall illustrate this more particularly when describing the interior of a telegraph office (§ 63): for the present it will be enough to know that in the one case the two springs from the *branch* wires are connected respectively with springs from the *earth*-wire at the junction station, while the main line is open through from end to end; in the other case, the two springs from the *branch* wires become connected respectively with the two wires that lead *up* the line, while the two wires from *down* the line become connected with the earth at the junction station. In the latter case the signals from London, instead of passing through to Dover, go down the branch,—it may be to Maidstone, to Ramsgate, and even to Deal; which gives London the immense advantage of being able himself to hold direct communication with the branch lines without any assistance from the junction station other than to turn on the branch, and afterwards to turn it off: this process is illustrated by the dotted lines at Ashford. The longest circuit we thus obtain on the district before us is from Deal to Rochester, 133 miles. I should mention, that while these turn-plates allow London and *up* stations to have access to the branches, they do not furnish the same privileges to Dover and *down* stations, for it is not yet required.

58. *Double Turn-plate.*—I have, however, fitted one double-acting turn-plate in the Tonbridge station (Fig. 12, § 64), in connection with the wires that proceed from my residence; it has but one cylinder, but the brass is so inlaid, and the springs so distributed, that my instrument can be put in communication either with London and the North Kent line, or with Dover and the branches, as occasion may

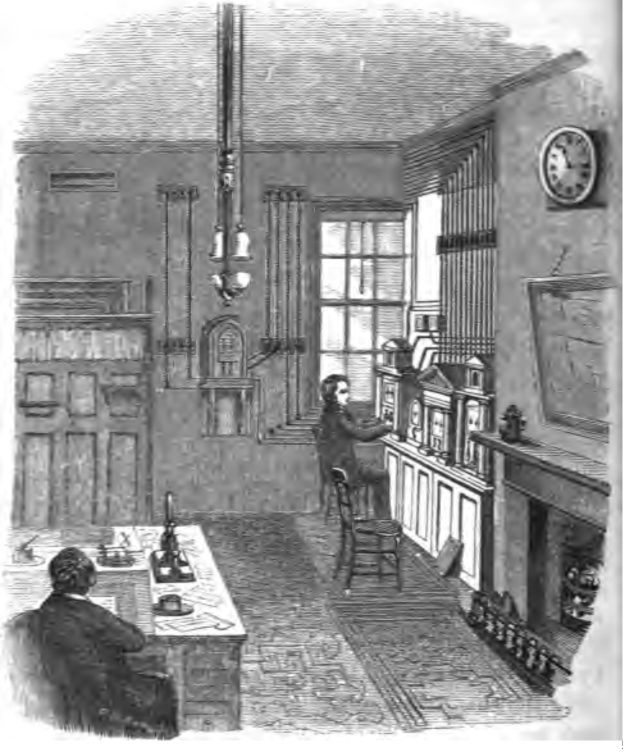
require. But, by putting this or any other branch instrument, in communication with an instrument *down* the line, the signals become *inverted*, and one or other of us must read backward, unless we attach to the instrument an apparatus for inverting the connections and so setting matters right. With a little practice, however, we read backwards very quickly.

59. *One-wire Turn-plate.*—There is a third species of turn-plate especially connected with the plan of the line. It is used for converting the double needle instrument into a single one with *both* wires on *one* of its needles; and is used should the line wires chance to get into contact. At the intermediate station it is so constructed that either the two *up* or the two *down* wires may be put on *one* of the needles: at the terminal stations it is so arranged that the two wires can be put on *either* needle; and it has an additional position by which London turns itself out of circuit, when Bricklayers' Arms station is turned in.

60.—The plan shews that the two wires from Dover bifurcate, or branch off, and terminate not only at London but at Bricklayers' Arms—wire 1 having a double termination like the letter Y, and wire 2 the same. Under such circumstances, a signal from Dover would divide at the junction, and half would go to each terminus. But the rule is, that the circuit shall be kept completed at London only; and Bricklayers' Arms can have possession of the line if the wires are at liberty, upon making application to London by means of the second telegraph, or wires 5 and 6, between these stations. Each station has a cylinder of box-wood with brass inlayings, and by a quarter rotation either station can break or complete the circuit. When London allows the other station to *complete* it, he himself *breaks* it, and again completes it when Bricklayers' Arms gives notice that he has finished. There are some special turn-plates at

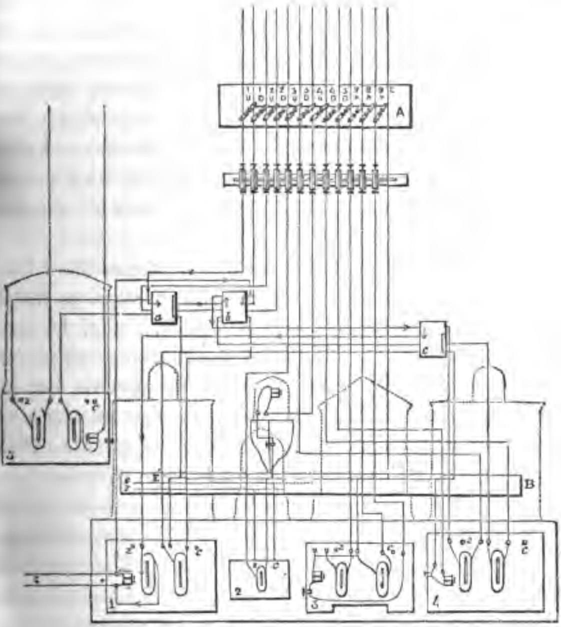
Gravesend and Woolwich by which Rochester or London can be put into direct communication with any of the smaller North Kent stations.

Fig. 11.



61.—The plan is drawn to scale, but for convenience the branches are set at right angles. The distances of the stations from London will be seen in the published rates at the end of the book. I have given the relative position in respect to Lewisham station of the Royal Observatory of Greenwich, which is distant 84 chains 20 links, as the day I hope may come when *time-wires* may be laid between

Fig. 12.



the Observatory and the railway for the transfer by telegraph of *mean-time*, and for determinations of longitude.

62. Telegraph Office.—In the course of our descriptions, we have more than once had occasion to refer to detached parts of the fittings and apparatus of a telegraph station; but now we will enter an office, and examine in full many matters which as yet have been but partially described. The Tonbridge Office will serve as our illus-

tration. By referring to the plan (Fig. 10), the commanding position of this station may be seen: it is midway between the capital and the coast, and in a central position in regard to the rest of the district. Here the conduct and management of the telegraph department is carried on; we have here our staff for maintaining the integrity of the line work, for cleaning and repairing the apparatus, and for keeping all stations supplied with battery power; and here we keep our stores. We befriend and assist all stations, and are their prime resource in times of distress and difficulty, helping on their messages when their own powers are crippled, and under all circumstances securing the successful working of the line.

63.—To make this station as effective as possible, I have furnished it with a very perfect set of apparatus, so that it will serve our present purpose admirably. Fig. 11 is an accurate sketch of the interior of the Tonbridge-office, just as it now appears. The telegraph table supports four instruments, and there is a fifth on a bracket on the wall. The wires, which are cotton-covered copper, enter the room above the window, and passing on are led in coils down the wainscot to their respective destinations. Some of the batteries are in the closet beneath the table, and others are in a battery room across the station yard. The screen to the left is the rubicon beyond which, by the necessary rules of the telegraph-service, the public are not allowed to pass.

64.—Fig. 12, which is drawn to scale, is a plan of the wires and instruments, shown in their places in Fig. 11. The wires may be studied in correspondence with the line-wires (Fig. 10), from which indeed they are led. They are numbered on their right to correspond. Nos. 7, 8, and 9 are the Tunbridge Wells wires; the letter U is put on the right side of the *up* wires, and the letter D of the *down* wires. An up wire is one that comes from the

London side of the shackle (§ 37); a down wire from the Dover side. The last wire, marked E, is the earth-wire, and is connected with the gas pipes.

65.—A is a mahogany tablet, carrying the old form of lightning conductors, one for each line-wire. A brass elbow, carrying points and a small ball, is attached to each wire, and a similar elbow is placed opposite to each, with the points and ball as near as possible to the other, without being in actual contact. This second set of elbows are screwed upon a slip of brass that leads from the earth-wire E, as shewn at the upper part of the system. The principle is that atmospheric charges, collected by the line-wires, shall discharge by the points or balls to the earth; and true enough, in thunder-storms, very vivid and loud discharges occur between these balls; but enough often remains to damage the instruments, so that these conductors are now rejected. The tablet next below A carries a set of lightning conductors on a new principle, of which an engraving (Fig. 13) and a description occur further on (§ 81, &c.).

66.—B is a tablet carrying three brass-rods. The upper one, E, is seen to be in connection with the earth-wire E, so that it is virtually a continuation of the earth-wire brought for convenience sake into near proximity to the back of the instruments. The others marked *c* and *z* are connected respectively with the copper and zinc ends of the battery. They extend along the tablet, and thus bring battery power close at hand to the instruments. I have drawn only a portion of them to prevent confusion.

67.—The table and its four instruments, shewn in perspective in Fig. 11, are here given in plan. The instrument next the window, at which the officer on duty is seated, and of which an elevation is given in Fig. 14 (§ 90), is the through instrument, communicating with London and Dover. 2 is the single-needle instrument, from which the sketch, Fig. 15 (§ 104) was taken. It is the termination of a group, of which Reigate is the commencement. 3 is one of two instruments, its companion being at Tunbridge Wells. 4 is the terminal instrument of the Maidstone group, the other termination is at Maidstone. 5 is one of two instruments, its fellow being at my residence. To include it in this plan, I have moved it a little from its true position. The dotted lines are the outlines of the instruments themselves. The relation of these five instruments with those at other stations may be readily gathered from the plan (Fig. 10). On one instrument only, No. 2, have I shewn how the terminals *c* and *z* (Fig. 3, § 23) are connected with the battery wires: brass wires are led down to them from the tablet B. I have shewn the terminals *c* and *z* on the rest, but have omitted the wires to avoid crowding. I have given outlines of galvanometers and electro-magnets on all the instruments, that the connections may be traced. From the earth-wire, E, a wire goes to all—to Nos. 1, 2, and 3 it passes *direct*, to 4 and 5 it arrives by a circuitous course by the intervention of the turn-plates, *a*, *b*, and *c*. The wires that go from the *left*-hand side of the galvanometer all lead *up* the line, or towards London. Those from the *right* hand side lead *down* the line, or *from* London. This may be seen by tracing the wires on the plan. When the wires cross in the plan, it must be understood that they do not touch each other. We can easily enough trace the wires that go uninterruptedly upward to the tablet A; but it requires some further description to understand what happens to those whose course is through a turn-plate.

68. The turn-plate *c* (§ 57) is for putting the Maidstone branch in communication with London; the double action turn-plate *a* (§ 58) is for putting the Superinten-

dent's instrument into connection with either London or Dover; the turn-plate *b* (§ 59) is for connecting both wires, either up or down the line, with the same needle coil, in the cases of connection between the line wires. I have already given the construction and general principles of the turn-plate. I have not been able to give here a section of their cylinders, as the plan is on too small a scale. We will, however, show their application by tracing wire 1; *first*, while the through communication between London and Dover is open; and, *secondly*, when communication is established between London and Maidstone.

69. Our first example will be the course of a signal passing from London to Dover. I have marked out this course by small arrow-heads. It enters the station by wire 1 up, the first wire to the left; it is led to the left side of the turn-plate *a*, which it enters by the second terminal; it passes *through* the box and the cylinder, and out on the other side by the terminal immediately opposite: the cylinder in this position has a bit of brass for this wire inlaid on either side, and connected by a brass bolt running through the cylinder. The current now passes in a direct line to the turn-plate *b*, entering it by the second terminal on the left-hand side, and passing in the direction of the contiguous arrow-head, leaving it by the first or upper terminal on the same side. In this drum, when thus arranged, there is inlaid a slip of brass, of sufficient length to allow the springs of both these terminals to press upon it. The current now goes on to turn-plate *c*, which it enters by the first or upper terminal on the left, and comes out by the second on the same side, the connection being exactly similar to that last described. It now pursues its course without interruption, to the telegraph instrument, which it enters on the left-hand

side of the left-hand coil: it circulates around the coil; and, on leaving it, circulates round the coil of the electro-magnet belonging to the alarum. Its course is then to the upper terminal on the right-hand side of turn-plate *b*, coming out by the second terminal on the same side, and so leaving the station to continue its course to Dover by down wire No. 1, D.

70. We will now trace the course of the same up-wire 1, when the turn-plate *c* is so turned that London is put in communication with Maidstone. The current pursues the same course as before, until it arrives at the turn-plate *c*: it now enters it by the upper terminal on the left side, and passing through the box and drum, leaves it by the upper terminal on the right side: it then descends to the left-hand side of the left-hand coil of the Maidstone instrument, No. 4; passes round the coil, and continues its course to Maidstone by wire 3 down, which becomes the No. 1 of the Maidstone branch at Paddock Wood, as shewn in the previous plan (Fig. 10, § 52). But the turn-plates are so constructed that while they make a particular connection for one part of the line, they provide perfectly for the part not so immediately concerned, by putting the wires that lead to that part in connection with the earth, and so the circuit is complete, as far as it goes. In the present instance, the same operation that turns 1 and 2 up-wires to Maidstone, connects the earth with the up side of the through instrument, and the communication is thus kept perfect between Dover and Tonbridge on the through instrument. By following with the eye, and in the reverse direction to the arrows, the wire that comes from the left coil of the through instrument, it is traced to the second terminal of the turn-plate *c*; the connection there is such that the circuit is continued through the box and cylinder to the second terminal on the opposite side; this

is in connection with the lower terminal on the same side, whence a wire descends to the common earth-wire. What has here been said of wire 1, equally holds good in respect to wire 2.

71. Turn-plate *a* has allowed the circuit of wire 1 up to enter one side and pass over to the other; but another position of the cylinder will close this circuit, and guide the current out by the terminal next above the one at which it enters. The wire from this terminal leads to the left side of the left coil of the instrument, No. 5; it passes out on the right side of the coil by the wire that passes upward, and which leads along part of the Tunbridge Wells branch line, and under the Hastings road to the companion-instrument in my study.

72. The action of this turn-plate may be better understood, by shewing how it operates in its three positions upon the two wires that lead to it from the No. 5 instrument. When this circuit terminates at Tonbridge station the course of the current is *directly through* the box; where there are three terminals, each connected with the earth by a common wire. When it is to be turned on and to terminate at London, the course is out of the box on the same side it enters; and when it is to terminate in Dover the course is through the drum, but so contrived as to come out by the pair of wires that pass between the two boxes, the arrangements being such that the earth is in each case connected with the circuit not then in use.

73. It would occupy too much time to describe the course of the whole series of wires; but, from what has been said, the careful reader will have no difficulty in studying the disposition of each, as they are all faithfully traced and correctly numbered. And, by comparing this plan with the general plan of the line, there can be

no great difficulty in connecting the special arrangements of this office with the general disposition of the line.

74. The mode by which both wires, either *up* or *down*, are connected with the left needle (§ 59), by turn-plate *b*, can be soon explained. When all is well the drum is so presented to the springs that strips of brass connect them in pairs, two pairs being on each side of the box. They were so connected when we traced the course of wire 1 just now (§ 69). Suppose the wires *down* the line are connected, and it is desirable to join them both on the left needle-coil inside Tonbridge station: from the right-hand side of the box the top wire leads to the left needle, and the two middle wires are the down wires, we merely turn the cylinder and a long slip of brass presents itself, and presses on the three springs, connecting at once both wires with one needle, and leaving the other needle out of circuit. The same is done for the *up* wire by turning the handle in the reverse direction, and presenting the brass slip on the other side.

75. *Bell Circuits.*—The character of the bell circuit (§ 31, 49) may be further illustrated from this plan. Wire 1 from London, in its course, after passing the left needle coil of No. 1 instrument has been seen (§ 69) to pass the bell-coil or electro-magnet, before it left the station on its way to Dover. The magnet would act and the bell ring; but if the bell-handle (§ 31) were turned, the current would mostly pass across at * by the stouter wires. These wires are continued round the room, and there is another bell-handle within reach of the clerk, who can make the short circuit at ⁑ without leaving his desk.

76. The Maidstone branch bell, No. 4, is on a third wire, distinct from the needle-coil. Wire 5, D, descends to the electro-magnet; it is continued from the magnet to the ringing key (§ 50, Fig. 8); it is thence led upward,

and joined to the earth-wire E′, on the tablet B. The Tunbridge Wells bell-wire 9 pursues a similar course; coming, however, first to the ringing key, and then to the electro-magnet, and away thence to the earth-wire. Wire, 4 U, which comes from Reigate, performs a similar office. I have given the outline of the bell-case, and the bracket on which it stands, to which latter the ringing-key is attached. As thus described, these three bells are always in circuit, and they are so arranged at all stations that have them; but here we have supplementary apparatus by which the short circuit can be made, when the noise of the bell, ringing for other stations, would interrupt business here.

Fittings such as we have now described exist in all stations, limited in each according to the requirements of the station. But from this hasty sketch the most careless reader will have seen what great facilities may be gained by well-arranged means of intercommunication between the instruments. I might have enlarged upon the capabilities of this station, and have shewn how we can take one part of a despatch from Dover by the telegraph at one end of the table, at the same time we are sending another part on to London by that at the other; how we can cut off the line and test its character; how we can watch the variations in insulation or the augmentation of resistance, and feel out the weaker points and provide remedies; and how the eye of the Chief Officer of the Department can command the whole line by night from his home, as well as by day from his office, and quick as thought can transmit instructions in all emergencies, in season and out of season; but we must pass on.

77. *Lightning Conductors.*—I have mentioned (§ 65) that lightning is no uncommon intruder into telegraph rooms; nor could we expect much otherwise, when thunder-storms

are at hand; for our line-wires are, of all things, most fitted for collecting it, and (as we have earth-wires in all offices) leading it, *viâ* our instruments, to the earth. I have said (§ 35) that the poles have protection to ward off actual flashes; and I have described (§ 65) our old method of in-door protection.

78. It does not appear, as far as experience has gone, that any fearful amount of lightning is likely to find its way into an office; for there are so many places near and about the buildings where the wire comes tolerably near to channels which would lead off an excess of charge. But it has very frequently happened that enough lightning has entered to fuse the wire of the bell-coils and needle-coils, and even partially to fuse wire of somewhat larger size, causing at the same time no little alarm by the light and noise. The fusions occur at the spots where the lightning leaves the wire to pass through the air to a conductor leading to the earth. It must be remembered also, that it is not necessary for a discharge to take place actually through, or by means of, the wire, to produce an effect on the instrument. For, if a flash occur anywhere in the vicinity of the wires, without itself entering them, it will, during its brief existence, disturb the natural electricity in the wire, and set it moving, and this to no small extent. And this phenomenon is likely to be much more frequent than the actual flash, and is, from its less violent character, probably somewhat more manageable.

79. I have contrived the lightning conductor represented in Fig. 13. Its two features are, that the wire coming from the line-wire before it arrives at the instrument, shall pass *withinside a metal cylinder in connection with the earth;* and that, in a part of its course within the cylinder, it shall consist of a piece of wire at least *as fine* as, or, what is better, a little *finer* than, is to be found in the bell or needle coils.

80. It is a well-known property of ordinary charges of electricity to expand, so to speak, and to occupy the outside surface of conducting bodies. If an ice-pail or metal vessel be insulated on glass legs, and a brass ball hanging to a silk thread, be employed to carry a charge of electricity from a common electrical machine to the *inside* of the vessel, it will part with *all* its charge the moment the two metals touch; and, on now applying a test instrument to the inside of the ice-pail, no electricity can be found there, the charge appears to have vanished. But, on presenting it to the *outside*, the charge is discovered there in its full quantity. I thence considered that, whatever arrangement I should insert in the course of the conducting wire, I might very advantageously place this arrangement *withinside a stout metal* cylinder, in good communication with the earth; so that the charge, in that part of its course, should be in all but contact with the earth connection, and further facilitated in its escape by having the latter on its *outside.*

81. Fig. 13 represents the lightning conductor very nearly in full size. A is a brass cylinder $\frac{1}{16}$ in. thick (shewn in section in the figure), in perfect metallic communication with the earth by the stout wire E, and insulated from the conducting wire by a disc of boxwood *a*, and a boxwood bobbin *b b*. The arrows shew the direction of the charge from the line wire *c* to the telegraph, to which it is screwed by the end *d*. The ends of the bobbin closely fit the inner surface of the cylinder; but it is slightly grooved in its course to receive two or three layers of a silk-covered copper wire *g*, finer than any elsewhere

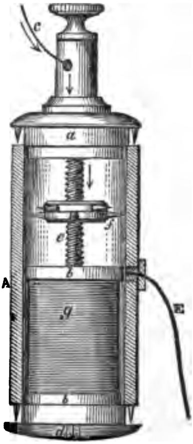


FIG. 13.

to be found in the instrument; the wire is in the circuit, commencing at the thick brass wire *e*, and terminating below at *d*; and is in very close proximity to the earth, — closer, in fact, than any other wire or piece of metal withinside the instrument or the office. The wire *e* is further furnished with two nuts *f*, fitted with points, made by gauge to approach almost within hairsbreadth of the cylinder. The boxwood terminations *a* and *d* are also capped with brass discs; from the upper disc, points approach the earth-cylinder; and from the lower end of the earth-cylinder, points are presented to the disc. The object of the coil *g*, of very fine wire, is, that from its tenuity, and from its juxtaposition to the earth-cylinder, it shall have a better chance of being burned, in an extreme case, than either the wire of the bell-coil or that of the needle-coil. The use of the points does not require any explanation.

82. The first set of these conductors were placed at Tunbridge Wells station; and not many weeks had elapsed before a lightning-flash entered the station, and it behaved with the apparatus as I had been led to expect. It passed safely through the stout wire *e*, and immediately on arriving at the fine wire *g*, it darted off to the cylinder, and, by its explosion, singed the silk and exposed the wire where I have placed a black spot, near A. In this case the flash was moderate, and the wire was not burned.

83. It went a step further; and another of its features was called into requisition, on 8th August 1849. During the night a violent thunder-storm occurred, the effects of which were especially manifested on the Ashford end of the Ramsgate branch (see Figs. 9 and 10): three poles, unprotected by lightning-wires, were splintered at Chartham, about two miles beyond Chilham; and the lightning entered both Chilham and Ashford stations, and by its

snappings and explosions, very much alarmed all on duty. When all was over, it was found that at Chilham, where there were no lightning-conductors, the wire of the bell-coil was burnt, and of both the galvanometer coils, and other severe explosions occurred about the apparatus; one of the No. 16 size copper wires was burnt and broken. At Ashford there were lightning-conductors on the two instrument wires, but not on the bell-wire (a few days previously the bell-coil had been saved by the lightning-conductor being burned; the latter was brought away to be examined, and had not been replaced). It was now found that the Ashford galvanometer coils, both of which had conductors, were saved; the fine wire, *g*, of the lightning conductor being burnt by the explosion in both cases, but the bell-coil, which was unprotected, was visited by the discharge and burned.

84. *Demagnetization of Needles.*—Lightning flashes occasionally disturb the polarity of the needles, and even demagnetize them. This is much more the case with the rhomboidal and the short needles than it is with the long ones; and the former have been found demagnetized even while furnished with these protectors: but in the storm above-mentioned, while the magnetism of the unprotected needles at the Canterbury station was disturbed, that of the protected needles at Ashford was undisturbed. I have sometimes been half induced to think whether the intense and momentary atmospheric charge may not act so violently and irresistibly on the *magnetism* in the needle, that it deflects it more rapidly than the *metal* can follow, and that the conflict thus caused by the *vis inertiæ* of the metal may overthrow the magnetic arrangement of the particles of steel. In like manner, it may be conceived that the loss of magnetism occurring in the ordinary use of the instrument, may be

mainly due to the incessant jars the needles receive as they strike against the stops (§ 87) by which their beat is limited.

85. *Magnetic Storms.*—Did any doubt remain of the electrical character of the *Aurora Borealis*, it would be removed by the phenomena presented by the needles of the telegraph, and often by the bells, during the prevalence of this meteor. At such times the needles move just as if a good working current were pursuing its ordinary course along the wires: they are deflected this way or that, at times with a quick motion, and changing rapidly from side to side many times in a few seconds; and at other times moving more slowly and remaining deflected for many minutes, with greater or less intensity, their motions being inconstant and uncertain. These phenomena have occurred less frequently on the part of the line between Reigate and Dover, which runs nearly E. and W., and on the part between London and Reigate, which is nearly N. and S. When, however, they do make their appearance on the telegraphs in those parts, we are prepared to expect auroral manifestations when night arrives; and we are rarely disappointed. The deflections, in their variations, appear to coincide with the various phases of the aurora. On the branch line running from Ashford to Ramsgate, these deflections have been a much more common occurrence, even when the other parts of the line were unaffected, and when no auroral phenomena were noticed. This branch nearly coincides with the curve of *equal dip*. I have represented the curve in the map (Fig. 9). A dipping needle inclines downward to the same angle, 68° 40′, at all places along this curve. Whether there is any relation between these two facts, remains to be investigated. On the same map I have drawn the curves of *equal declination;* the needle points to the same number

of degrees west of the north at all places along the direction of these curves. The declination at Deal and Dover is 22°, at Tonbridge it is about 22° 27′.

86. It is most remarkable that during the year 1849 these deflections were rare and trivial, whereas in 1847 and 1848 they occurred many times on the main line, and were of almost daily occurrence on the Ramsgate branch, and to such an extent that the instruments required unusual precautions to enable them to give signals; for if the needles were already deflected to the ivory stops (Fig. 14, § 90), we could give them no further deflection in that direction. The needles are also subject to feeble secular deflections, corresponding with certain hours of the day. The wires also collect at times electricity from the atmosphere, and affect the needles.

87. *Movable Studs.*—So much were we inconvenienced during 1848, that I was compelled to provide a remedy. On the face of the instruments (Figs. 13 and 14) are seen a pair of small studs, which are of ivory, and which give a limit to the deflection of the needle; and if by any extraneous cause, and without any act of ours, the needle should be driven hard up against one of the studs, our attempt to deflect it in that direction by an ordinary signal would not be manifest; for it is there already. But if under such circumstances the studs were removed, and the needle allowed to go as far as the natural force could deflect it, we could *increase* that deflection by sending our usual currents in the proper direction; so that if the studs are made to follow the needle into its new position, and are so placed that the needle shall be half way between, we can still get each kind of deflection, although the needle shall have been much deflected from the perpendicular, providing always that it has not reached the limits of deflection; which would be unusual.

88. With the axis of the needle as a centre, I traced a semicircle and cut a groove in the face of the instrument, as shewn in Fig. 14. On a movable circular disc behind this groove, I placed the ivory studs. The button visible between the handles of the instrument carries a wheel; a cord passes over this wheel and over the stud-discs of both needles, and by moving the button the studs are readily made to follow the motion of the disturbed needles.

89. *Movable Coils.*—A weighted-needle, like that of the telegraph, has necessarily a tendency to attain the vertical position during the first stage of making a signal, namely, when one pole of the battery has broken the circuit, and has so cut off the external action, and the other pole has not yet touched the stud (§ 25) to repair the breach; this may give a jolting or oscillatory character to the signals, if they are not cleverly managed. To obtain a vertical needle during the time of these deflections, I have made the coils movable by mounting them instead of the studs on the above-named discs; and when the needle is deflected I do not follow it with the coil, as is done with the sine-galvanometer (§ 16), but I *move the coil away* until the needle is, as it were, drawn back to the vertical. The angle, however, between the needle and the coil is in this case greater than when the coil is not moved, because the gravity of the needle acts in opposition to the deflecting power, when the needle is at an angle with the vertical, and so reduces the angle. These two plans have been combined in one instrument by the Telegraph Company.

90. **Double-needle Code**—Having described the apparatus and means employed for producing at pleasure the transmission of signals to distant places, it now remains to us to explain the manner of interpreting these signals, so that each person shall understand the ideas the other would convey. And first in importance we have the "Double-

needle Instrument," shewn in elevation in Fig. 14, and to which we have already had occasion more than once to refer. The case is mahogany; the dial brass, silvered; the studs vory; the needles magnetized steel; the letters are black; he handles mahogany. The circle on the lower part of he instrument is the *silent apparatus*, elsewhere described.

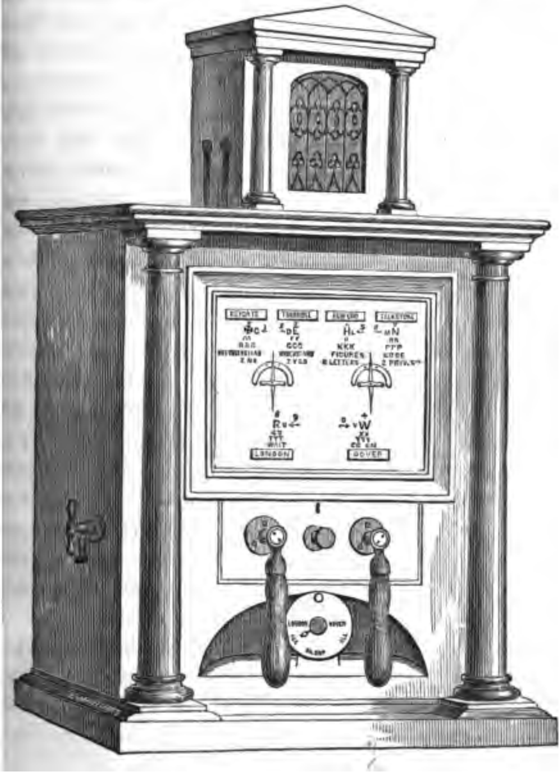


FIG. 14.

It is here turned to all stations, and so that signals from London would appear on this instrument and pass through it, and onward to Dover. By pointing the index to the engraved name, the required connections are made.

We have to describe how, out of only *two* needles, each of which has but *two* movements, the telegraph alphabet is formed. On the face of the instrument are the letters of the alphabet, arranged, as will be seen, *seriatim* in two lines, beginning at the left and ending at the right, as in ordinary writing. The commencing series from A to P is above the top end of the needles; and the concluding series from R to Y below the bottom end. It will also be seen that some letters are engraved *once*, some *twice*, and others *three* times. To make a letter engraved once requires *one* motion of the needle; to make one engraved twice, *two* motions of the needle; and to make one engraved three times, *three* motions. In respect to the UPPER row, the needle *nearest* to the letter is moved, and it is moved so as to point *toward* the letter. In respect to the LOWER row, *both* needles are moved, and their *lower* end is made to point in the direction of the letter required. Six of the letters, C, D, L, M, and U, V, require a twofold motion of the needle or needles, first to the right then to the left for C, L, and U, and first to the left then to the right for D, M, and V. These six letters are engraved *intermediate*, and with a double arrow between. The alphabet produced by this arrangement is of a simple character, and is very readily acquired. To the stranger, it appears confused; but when he has the key to it, the difficulty disappears: it might at first sight appear that a dial instrument—a telegraph, that is, provided with alphabets engraved on a circular dial, and an index made to revolve and point to any required letter, is more simple. Several such telegraphs exist, and among them are some very happily arranged; and there is something so simple in the fact of being able to point to any desired letter, that it is no wonder the public generally may, on a hasty glance, and before studying the practical merits of the case, be ready to decide in their favour, and prefer them to any other plan, the A, B, C of which is less obvious.

91. The French government seemed greatly afraid of a new alphabet; and when they had determined upon adopting an electric telegraph, must needs require that it should be so constructed as to present to the eye similar signals to those shewn by Chappe's semaphore. Chappe's semaphore is like the letter T; the vertical rod is fixed; the horizontal rod can be moved into various angles in respect to the vertical rod; the two short arms can be placed in various angles in respect to the horizontal rod. In the electrical fellow, it was not possible to move the horizontal rod, so it was allowed to remain horizontal, and the short arms were alone made movable; they have thus limited their power. As might have been expected, the *employés* found more difficulty (according to Moigno) in familiarising themselves with the manipulation of this new instrument, than they would have done in learning a new code of signals.

92. But is it such a *very* serious matter to learn another alphabet? Every schoolboy, nowadays, knows some half-dozen alphabets: there are ROMAN letters large, and Roman letters small; *MANUSCRIPT* letters large, and *manuscript* letters small; Old English large, and *Old English* small; Greek large, and *Greek* small, and so on, and all different, and not one of them in which the letters are represented by so few *strokes of the pen* as are the telegraph letters by *beats of the needle*. Take one of our plainest alphabets as an example; the ROMAN CAPITALS,

for instance, and place a few of them in juxtaposition with the corresponding telegraph signals:—

A	\\	E	/	G	///
B	\\\	F	//	H	\

93. The simplicity of these symbols is obvious. Two diagonal and one horizontal line are required for the Roman A; two diagonal lines for the telegraph A; one vertical and three horizontal lines make the Roman E; one diagonal the telegraph E, and so on; the difference being that all the world have learned the Roman alphabet; but only a chosen few have studied the telegraph symbols. That the latter really are simple and distinctive; that they are full of meaning and very legible; that they are applicable to ordinary language, and good, ay, very good! no one will for a moment doubt, who has seen the rapidity and accuracy with which a telegraph officer receives a despatch.

94. To one who sees a telegraph in operation for the first time, the effect borders on the marvellous; setting out of the question the fact that the needles are caused to move by an individual perhaps a hundred miles off; the motion of the needles hither and thither, quicker than the untrained eye can follow; the want of all apparent order and rule in their movement; the ringing of the changes between one and the other, and both; the quiet manner in which the clerk points his needle to the letter E, in rapid intervals, implying that he understands the word; while to the uninitiated looker-on, all is wonder, and mystery, and confusion; and the rare occurrence of the clerk pointing to ✠, implying he did *not understand;* and, finally, the quiet manner with which the clerk tells you, very coolly, as the result of his operations,—that "The very pretty girl with bright blue eyes

and long curls *has* sailed for Boulogne in the *Princess Clementine*, now leaving Folkstone Harbour; and that she *is* accompanied by the tall, handsome man, with the dark moustache and military cloak:" as he tells you this, and says, "Message and answer, forty words, two rates at 10*s*. 6*d*., one guinea, porterage a shilling,—one pound two." If you happen to be the papa of the pair of blue eyes, you are bewildered, and wish you were an electric current, and could be sent after them.

95. *A propos* of sending something more *solid* than an electric current along the telegraph wires, the following anecdotes are strictly true; and, if any kind friend of the individuals in question should have the opportunity, it would be common charity to present them with a copy of this book—it would be eighteenpence not ill-spent.

At Dover, an individual presented himself at the Telegraph-office one afternoon with a sum of money, and desired the clerk to send the *money itself*, in propriâ formâ, up to London by telegraph, to be forwarded to a certain banker's. The money was to take up a bill due that day, and there was no time to send it by train. He seemed perfectly surprised that it could not be sent.

At London, a servant in livery came to the office, heated and out of breath, with a small parcel to be sent by telegraph to a distant part of the county. It appears he had instructions to send it by train, but he arrived just too late for the train, and, as it was of consequence, he thought he should get out of his dilemma and expedite matters by adopting this course.

96. But to return to the alphabet: and here, by-the-bye, I should mention that the voltaic current is put into circulation and the needles deflected by a right or left motion given by the hand to the handles on the lower part of the instrument. Having described the general arrange-

ment of the code, I need not go through the letters *seriatim*,—the reader will manage that for himself,—but shall describe the arbitrary signals, also engraved on the face. The symbol like a Maltese cross ✠, which we term "stop," is used by the sender at the *end* of every word, and by the reader when he does *not understand* any particular word. In these cases it is merely pointed to by a left-hand deflection of the needle. The letter E is pointed to by the reader the moment he understands a word. Two beats to the letter E are used for "yes." For instance, to spell the word Hen, we make the four following beats:—

The first beat ( ) is made with the right needle, and is H
„ second (/) „ left „ E
„ third (/) „ right „ N
" fourth (\\) „ left „ ✠

the last beat being the end of the word. If the correspondent *understands*, he makes with the left needle the *first* of the following deflections; if he does not, he makes the *second* :—

/ \\

Some of the letters are engraved smaller than others, not for any other reason than to pack them comfortably on the engraved plate; there would be no room if all were made large.

97. *Wait* and *Go on* are engraved on the instrument, and are useful signals. If London calls Dover at a time when Dover is otherwise occupied, and unable for the moment to attend, Dover exchanges signals with London and discovers who wants him, and he then points the lower end of his needles to the letter R, or word "Wait." When he is disengaged and ready to take the message, he calls London, exchanging signals in the usual way, and points the needles to W, or "Go on."

98. But I must explain what the "usual way" is; for it

is above all things important for the two stations concerned in any intercommunication to have a good mutual understanding before they begin, that the receiver may know who is sending, and the sender may know that the right station is receiving the message. The names of six stations are engraved, one over each of the large letters; and being one of the "through" instruments, namely, copied from that at Tonbridge, marked No. 1 in Fig. 12, the names are those of the first-class stations on the main line, beginning with London at letter R, and going round in the direction of the hands of a watch, to Reigate, Tonbridge, Ashford, Folkstone, and, finally, Dover, at W. This order of station symbols is preserved throughout the whole district, the first of any series being at R, and the last at W, if there are as many as six. If, now, London wishes Tonbridge, he deflects the needle a few times towards E; each beat rings the Tonbridge alarum, which, as we have seen (§ 69), is on the same wire as the left needle, and this attracts the attention of the clerk, and seeing his signal, he turns off his bell needle and replies, by himself repeating the signal; so far so good: London has gained the attention of Tonbridge, and is aware of it. He then deflects his needles to R, his own signal, by which Tonbridge discovers who wants him; Tonbridge repeats the R to show that he understands. London calls him, and then the message begins; Tonbridge acknowledging word by word by giving the letter E, "understand;" or if he has doubts of any word, gets it repeated by giving the "not understand" signal. When all is over, London makes two beats of the left needle to the left, and if Tonbridge has nothing to say in reply, he also makes two similar beats, and so the matter ends, the clerk at Tonbridge proceeding to forward the message by hand to its destination.

99. *Private Codes.*—Two telegraph officers, placed one

at Dover and the other at London, can easily modify this code, so that the intermediate stations who may see their signals shall not be able to read them. By agreeing that the right-hand deflections are to be read as left-hand, and *vice versa*, of either or both needles; or by regarding the left as a right-hand needle, or both as either, a great variety of private codes can be constructed; the words of which can be read almost as rapidly as in the direct code. The cabalistic-looking words, "Rnfy rohc ox fmirohb oh mihcih?" would mean, by one of these codes, "What wind is blowing in London?" By another code, the queer words, "Xkecoam ywaoh ovxy mefy fiw yne yolex," mean "Special train just left for the *Times*." It would be a slow process to send the above as *mere* words; but, with the key in mind, they can be transmitted very rapidly.

100. The digits are readily given; they are arranged *seriatim* over some of the letters; and by having a previous understanding in respect to any particular beat of the needle, that it is intended for the *figure* it points to instead of the *letter*, the affair is simple enough.

101. The letter H given alone, and followed by the ✠, is our private signal that the next following beats are figures; and to shew that he catches the idea, and understands what is coming, our correspondent repeats the H and the stop. If after this we give the beats which as letters would spell the word HEN, we mean the figures 437; these figures being placed over the said letters. The letter W dropped in among figures, serves as the decimal point (.), or as the distinctive mark (″) between the terms in mixed figures. Talking of money, HEWN would be 43*l*. 7*s*.; of length, it might be 43 ft. 7 in.; of time, HWEN would be 4h. 37m.; and so on.

We have a signal for the *period* or full stop, and for *paragraphs;* and we have one for *underlining* words.

And we have many very valuable special signals. There is also a signal among the clerks for *laughing*, and one for the *whistle* of astonishment.

102. There is also as much character in signalling as there is in handwriting; and it is almost as difficult to counterfeit the one as the other. We know at once, after a few signals, the name of the clerk who is at the distant instrument; one, perchance, is grave and firm in his deflections; another is sharp and quick; this one is wild, that one is gentle; one is patient, another hasty; and when a recruit attempts, he is very soon discovered. The temper and habit of mind is very often displayed; and the patience is at times sorely tried, and put to the test. I should add to this, that the experienced manipulator is so well versed in the signals that he can work equally well with a blank dial.

103. *Secret Codes.*—The extent to which the code may be employed for secret intelligence is unlimited; it is in the power of the government, and also in that of private individuals, as occasion requires, either to couch their ideas in mysterious language or to interchange the letters of the alphabet in any way they please, so as to entrust us with despatches, the interpretation of which is only known to themselves; and this is very frequently done, the condition on our part being that the despatch be declared a *cypher* one. As secret language is more valuable to the sender, and requires longer time and greater caution on our parts, the charges are higher.

104. SINGLE-NEEDLE CODE.—From what has been said, a few words in addition will suffice to explain the Single-Needle Code. With two needles, the greatest number of beats to form any letter is *three;* with the single-needle code some of the letters require *four* beats; and as there is but one needle, the combination of motions to form the

letters is greater and more varied, and conversation is consequently less rapid. Fig. 15 is an elevation of a single-needle instrument. The alphabet is engraved right and left of the needle, more in reference to convenience, and to the usual habit of beginning the alphabet with A, and going onwards to the end, than in regard to any particular direction in the beats of the needle, the only general rule being that in the letters which are here placed to the *left* of the needle, the *last* beat to make any given letter is a *left-hand* beat, whatever other beats may enter into the

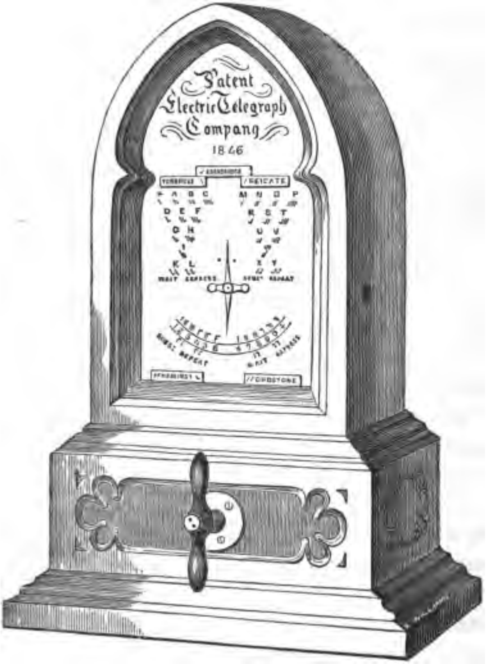


Fig. 15.

production of the letter; for instance, L requires four beats, but they are right, left, right, *left*, finishing with left; so again the letters placed on the *right* of the needle finish with a right-hand beat, as W, which is composed of four beats, three to the left, and the *fourth* to the right. The system pursued in the formation of this alphabet is simple enough, and soon acquired when the principle is once gained. Beside each letter is placed a symbol of one or more diagonal lines, sloping to the right or to the left, or both ways. Some of the diagonals are full length, the others half-length; the direction of the diagonal is the direction of the deflection, and there is to be made a deflection for each diagonal, and the deflection corresponding to the half-length is made first. D, for instance, is made by a beat to the right, followed by one to the left; R by one to the left, followed by one to the right; H by two to the right and two to the left; W by three to the left and one to the right, and so on. The scheme of the code is, one, two, three, and four left-hand beats for the first four signals; then *one* right-hand and one, two, and three left-hand beats for the next in order; then *two* right-hand and one and two left for the next; then *three* right-hand and one left; then a left, a right, and a left; and, lastly, right and left, right and left, which reaches L, and completes the first-half of the series. The other half are the counterparts with the beats reversed.

105. The private signals for stations on single-needle groups are quite arbitrary, and are selected from these symbols as convenience dictates; but having once determined upon a signal, when the bell is rung and this signal is made, the station to which it belongs is expected to answer it. The instrument before us belongs to the group between Tonbridge and Reigate (No. 2 of Fig. 12, § 64), and on it are five small labels, bearing the names and

private signals of the five stations constituting this group. If the clerk at Reigate should hear the alarum, and see the letter M repeatedly made, he knows that *he* is wanted; one beat to the *right*, or M, being his signal. This code also is used if accident converts the main line for the time being into a single needle series (§ 59). All that has been said in regard to the manner of conversing and responding by the other code are applicable to this. The *stop* is given in the same way, and so is *understand;* and there is a series of digits and special signals just as with the other instrument. The digits are engraved below the needle, and the lower half of the needle is regarded in making them; in the Fig. 4, for instance, the lower half of the needle is moved once to the right and once to the left.

106. *Rate of Signalling.*—The rate at which newspaper despatches are transmitted from Dover to London, is a good illustration of the perfect state to which the needle-telegraph has attained, and of the apt manipulation of the officers in charge. The mail, which leaves Paris about mid-day, conveys to England despatches containing the latest news, which are intended to appear in the whole impression of the morning paper. To this end, it is necessary that a copy be delivered to the editor in London about three o'clock in the morning. The despatches are given in charge to us at Dover soon after the arrival of the boat, which of course depends on the wind and the weather. The officer on duty at Dover, having first hastily glanced through the manuscript to see that all is clear to him and legible, calls London and commences the transmission. The nature of these despatches may be daily seen by reference to *The Times.* The miscellaneous character of the intelligence therein contained, and the continual fresh names of persons and places, make them a fair sample for illustrating the capabilities of the

electric telegraph as it now is. The clerk, who is all alone, placing the paper before him in a good light, and seated at the instrument, delivers the despatch, letter by letter, and word by word, to his correspondent in London; and although the eye is transferred rapidly from the mannscript-copy to the telegraph instrument, and both hands are occupied at the latter, he very rarely has cause to pause in his progress, and as rarely also does he commit an error. And, on account of the extremely limited time within which the whole operation must be compressed, he is not able, like the printer, to *correct his copy*.

107. At London there are two clerks on duty, one to read the signals as they come, and the other to write. They have previously arranged their books and papers; and, as soon as the signal for preparation is given, the writer sits before his manifold book, and the reader gives him distinctly word for word as it arrives; meanwhile, a messenger has been despatched for a cab, which now waits in readiness. When the despatch is completed, the clerk who has received it reads through the manuscript of the other, in order to see that he has not misunderstood him in any word. The hours and minutes of commencing and ending are noted, and the copy being signed is sent under official seal to its destination, the manifold facsimile being retained as our office copy, to authenticate verbatim what we have delivered. This copy and the original meet together at the chief telegraph-office at Tunbridge, early in the day, and are compared. When the work is over, and the despatches have reached their destination, the clerks count over the number of words and the number of minutes, and find the rate per minute. From twelve to fifteen words per minute has become a very ordinary rate; seventeen or eighteen words per minute is of very common

occurrence, and even twenty words. Indeed, when all is well and the insulation is good, seventeen or eighteen words is likely to be the average.

108. The following list of eleven despatches, worked up during the week ending August 4, 1849, may be taken in illustration. I have given the number of words, and the rate per minute:—

364	words	13½	words per minute.
166	"	8¼	" "
383	"	14½	" "
447	"	17¼	" "
101	"	20⅕	" "
288	"	17	" "
274	"	15¼	" "
106	"	15⅐	" "
102	"	12¾	" "
334	"	17½	" "
73	"	18¼	" "

109. On 11th December 1849, to the great astonishment of the merchants and bankers of Paris, three gentlemen appeared on 'Change in that city, at half-past one P.M. having with them 150 copies of *The Times*, printed and published in London on the morning of the self-same day; and not only did *The Times* contain the Paris news up to *noon of the previous day*, but actually the closing prices of the Paris Bourse of the *previous evening*.

110. The electric telegraph contributed in no small degree towards the accomplishment of this feat. At eight minutes past one A.M., the despatch of 321 words, and the Bourse prices, equal to 55 words, were delivered into our charge at Dover, having been conveyed thither from Calais, in the ordinary mail boat. In exactly *thirty-two* minutes, namely, at forty minutes past one, a correct copy of both these documents was handed in by us to *The Times* office

in London. The despatch occupied us eighteen minutes, being at the rate of 17⅝ words per minute; the Bourse prices, two minutes. In respect to the latter, the rate is high, because the larger portion is anticipated, the mere fluctuations being all that is new. There was nothing extraordinary to us in this, quickly as it was accomplished; indeed, on the following morning the writer in London was fairly beaten by the telegraph,—the words were read off faster than he could make a clean copy of them.

The despatch in *The Times* of 1st Jan. 1850 was in our possession but thirty-nine minutes: it was read at the rate of 17⅛ words per minute. I tried an experiment with this despatch on the same day, and while I wrote, the clerk at Tonbridge read it from Dover at the rate of 23⅗ words per minute; signals being very good.

111. Railway Telegraphs.—The electric telegraph is greatly indebted to railways; if not for its existence, at least for the friendly hand they have held out to it, and for the protecting care with which they have guarded it: indeed, the invention would long have remained immatured and void of practical existence, had not the railway prepared for it a pathway from place to place, along which its capabilities could be tested. Nor has the child been ungrateful to its foster-father; it has made a tenfold return for all the protection that has been extended to it. The quiet poles and silent wires, the zinc and the vitriol, the brass, the ivory, the earthenware and the gutta-percha, are far more concerned in the working economy of a railway than the proprietors may suppose.

112. As an illustration of the amount of service it may render to a railway, take the telegraph work done at Tonbridge station for the three months from 1st August to 31st October, 1848. By referring to the message-book, in which it is the rule that all communications shall be

entered, it appears that upwards of *four thousand* messages passed in that interval, which I have roughly classified as follows :—

		Messages.
1.	Concerning ordinary trains	1,468
2.	„ Special trains	429
3.	„ Carriages, trucks, goods, sheets, &c.	795
4.	„ Company's servants	607
5.	„ Engines	150
6.	„ Miscellaneous matters	162
7.	Messages forwarded to other stations	499
	Total	4,110

113. (1.) To make a full analysis of these seven groups of messages would be tedious, the reader can imagine for himself that, in regard to trains, all which concerns the progress and safety of a train has been at one time or other the theme of telegraph signals, and that, from the time it starts until it reaches its journey's end, it "casts a shadow before," yes, many miles before, to notify its coming, and leaves "a track behind" as distinct and as palpable to the mind's eye as if the eye itself were present to see it. Indeed, this is so realized, that we are in the common habit of saying I just *saw the train pass* this place or that, when all we really saw was the *telegraph signal.* If trains are late, the cause is known; if they are in distress, help is soon at hand; if they are heavy, and progress but slowly, they ask and have more locomotive power either sent to them or prepared against their arrival; if there is anything unusual on the line they are forewarned of it, and so forearmed; if overdue, the old plan of sending an engine to look after them has become obsolete—a few deflections of the needle obtain all the information that is required.

114. (2.) *Special Trains* are nowhere really *special* unless on a telegraph railway. My idea of such a train is, that it can be had for the *asking*, and can have a *clear course* before it. On a railway like the South-Eastern, which is the high road between the Continent and the capital of the British Empire, couriers may arrive from abroad, as indeed they do, at all hours, and without any previous notice, and require immediate means of reaching London. Should the *Ondine* arrive at Folkstone bearing despatches for the morning papers, full of eventful news of "wars and rumours of wars," of tottering thrones and falling diadems, —and how oft was this the case during the eventful year 1848?—the courier need not care at having just missed the train, nor fear of being too late in London to save the press for the *First Edition.* If he finds no engine at Folkstone, the telegraph will soon obtain him one from where there is one to spare; and not only so, but when he starts will clear the road before him, and give timely notice to the train in advance to move aside and let him pass. Nor need the traveller by the previous train have any fear, as otherwise he might, on such a line as this, that some ramping, raging engine, conveying a special train, shall rush upon him unawares, with destruction and death upon its wings. The guards in charge of his train are well advised by telegraph of what is following in their wake, and they know the time and place to move aside and let the coast be clear. Four hundred and odd signals in three months will show how greatly the course of special trains, and the comfort of their passengers, must be regulated by the telegraph.

115. (3.) A given amount of work is accomplished with a less amount of rolling-stock on a well-worked telegraph railway than elsewhere; and of the stock that is employed, there is much less unnecessary wear and tear in

running about to stations where it is not wanted. The *money-value* of this use of the telegraph is great. It is of daily, and almost hourly, occurrence for stations in unexpected want of carriages and trucks, to obtain them, by means of telegraph notice, from other stations who can spare them ; and thus the surplus stock is much less than it must otherwise needs be. About a thousand carriages of various kinds, and sheets for protecting goods trucks, were required by telegraph in the three months before us. The urgency of these requests sometimes amounts almost to the ludicrous. To some small station, say Headcorn, an unexpected inpouring of hops arrives from the neighbouring gardens ; he has very few trucks, very few sheets, he has just sent his last away ; the heavens look black and threatening—big drops begin to fall ; his warehouse and his tents are full. He makes known his distress to Ashford, in vain ; to Canterbury, nearly in vain ; to Tonbridge —he gets some trucks, perhaps, but no tarpauling to cover them ; to the goods department, in the Kent Road, London, whence his wants, perhaps, are all supplied. If, again, all this were to be done by letter, conveyed by train, the opportunity would be lost, or the mischief would be done, before his wants could be supplied. For the letter would first go to head-quarters at London, where probably would be kept the returns of the distribution of the rolling-stock on the morning of the day in question ; the officer in charge would know at what station, say Canterbury, there appeared in the morning a good supply. He would write by the next train to Canterbury. But the evening would, by this time, have arrived, or the stock at Canterbury might now be engaged ; or, if any could be spared, there might be no ready means of forwarding it.

Besides these messages arising out of the daily wants of rolling-stock, there is the plan of furnishing the chief office of the goods department, with a telegraph report every morning, from all stations, of the stock at that time at each station.

116. (4.) Six hundred and odd messages, in three months, of communications between the Management and the heads of departments, and between the latter and their subordinate officers, is a good illustration of the comparative ubiquity the telegraph confers upon the Direction of a railway. The hours of needless delay and the miles of profitless travelling, which are thus saved are great; and anxiety of every kind is mitigated. No small amount of practical confidence is created, from the fact that the Management can issue instructions to meet emergencies, and can be consulted by their officers from all parts of the district in any time of need.

117. (5.) We have already remarked, that the telegraph communicates the plight of distressed trains to stations provided with spare locomotive power; it also regulates the distribution of engines when any mishap has occurred requiring a fresh supply; or when any undue call has been made upon the ordinary stock. But the actual saving, in locomotive power, by enabling the number of pilot engines to be reduced, is of itself a most important feature in the economy of the electric telegraph. In the district in question, there are certainly two stations, if not three, which once had pilots, but are now without; when required, engines are obtained by telegraph. It would appear that, on a part of the line not yet provided with the telegraph, a pilot might be superseded if the telegraph were there. Now, as the *maintenance and wages for one single engine* amounts to a *larger sum* weekly than is required to pay our *whole staff of telegraph clerks*, and the *mechanics and labourers* employed in cleaning and repairing the instruments, and maintaining the integrity of

the line work, if only one engine is superseded, we have a notable set-off in favour of the telegraph.

118. (6.) All other communications have been classed under the head of Miscellaneous. No matter what the subject or when the hour, the lightning signal is obedient to orders.

119. (7.) We appear also to have had just 500 messages to transmit; either to forward on in due course to the smaller groups, or to help on for other stations in times of bad insulation, or of other distress. When to this we add the signals passed on matters essentially connected with the working of the telegraph itself and its maintenance; and our experiments upon the signals and testings, we have no lack of evidence of the great capability of the instruments, and that they are by no means idle.

120. In *The Times* of the day on which I am writing, is an illustration of the condition to which a train may be reduced when unbefriended by the telegraph. A "Constant Reader" had been spending the day at a popular watering-place, and, in common with very many more, prolonged his visit until the "last train." The train arrived, and when all were seated twenty-seven carriages were filled. The engine had rattled on joyously before this large addition to its load was made; but now it commenced panting onward with deep asthmatic labourings. "We proceeded," writes our friend, "at a snail's pace, stopping, as usual, at the various stations until we reached the centre of the long tunnel, where we were entirely brought to a stand, and remained almost suffocated by steam and smoke for thirty-five minutes, amidst the screams of the women in the second and third class carriages, who were in total darkness, and sharing with us the fear of the next train, which was considerably overdue, crushing us. . . . "—No

very pleasant predicament assuredly! and he very reasonably asks, in continuation, "if the train was too long for one engine, why not have had two?" Ay, there was the rub. But there was no getting another then and there. The driver may have seen that the great influx of passengers was as much as his engine was equal to, but he had no help for it; he must either do his best, or leave some of the passengers behind: there was no telegraph to call for help.

121. As a contrast to this: the very next day, one of the charitable institutions in London gave the children a trip to Tunbridge Wells, and they filled a long special train. The engine which brought them from London was not able of itself to take them up the incline where the branch (§ 36) leaves the main line at Tonbridge; and the pilot engine was absent on another equally pressing engagement. Quick as thought, the Tunbridge Wells engine was ordered by telegraph to come and help; and it was ready at the junction even before the train that required it. I could fill the book with anecdotes such as these.

122. On New Year's Day 1850, a catastrophe, which it is fearful to contemplate, was averted by the aid of the telegraph. A collision had occurred to an empty train at Gravesend; and the driver having leaped from his engine, the latter started alone at full speed to London. Notice was immediately given by telegraph to London and other stations; and while the line was kept clear, an engine and other arrangements were prepared as a buttress to receive the runaway. The Superintendent of the Railway also started down the line on an engine; and on passing the runaway, he reversed his engine and had it transferred at the next crossing to the up-line, so as to be in the rear of the fugitive; he then started in chase, and on overtaking the other, he ran into it at speed, and the driver of his engine took possession of

the fugitive, and all danger was at an end. Twelve stations were passed in safety: it passed Woolwich at fifteen miles an hour: it was within a couple of miles of London before it was arrested. Had its approach been unknown, the mere money value of the damage it would have caused might have equalled the cost of the whole line of telegraphs. They have thus paid, or in a large part paid, for their erection.

As a contrast to this, an engine some months previously, started from New Cross toward London. The Brighton Company have no telegraphs; and its approach could not be made known. Providentially, the arrival platform was clear; it ran in, carrying the fixed buffer before it, and knocking down, with frightful violence, the wall of the Parcels Office.

123. *Uses of the Electric Telegraph to the Public.*—A characteristic feature of the telegraphs in the British empire, and for which provision is made by law, is that they "shall be open for the sending and receiving of messages by all persons alike, without favour or preference, subject to a prior right of use thereof for the service of Her Majesty, and for the purposes of the Company," and, of course, "subject to such equal charges and such reasonable regulations as may be from time to time made by the said Railway Company."

124. The charges made by the ELECTRIC TELEGRAPH COMPANY, and also those made by the SOUTH-EASTERN RAILWAY COMPANY, are fully given in the advertisements at the end of the work. The latter are based upon a rate of 1½*d.* per mile for twenty words, 5*s.* being the minimum charge; the former upon a rate of 1*d.* per mile for twenty words, for the shorter distances, and a decreasing rate as distance increases.

125. I am not disposed to think that any such reduction,

as could prudently be made in these rates, would produce an adequate increase of telegraph business. Where the mail service is so perfect, and the postal rates are so low as in England, no reduction in our tariff could bring us into competition with the General Post-office, and take much from the letter-bag. We have a separate existence: the electric telegraph is to do what the mail train cannot; it is to distance the carrier pigeon, to outstrip the wind, to strike the hour-glass from the hand of time, and level the boundaries of space. And so, while it may happen that matters are occasionally transacted by telegraph which could have been accomplished by ordinary modes, yet it must mainly be called into requisition when *all other means fail*,—when, in fact, service is required which it is physically *impossible to accomplish otherwise*. In a great commercial country like this, and in a country where social relations are so extensive, these emergencies are of hourly occurrence, and, as we learn from the despatches entrusted to us, are of the most varied character.

126. Could we raise the veil of secrecy which, by our compact with the public, we are bound to hold over the correspondence entrusted to us, we could set forth a volume of domestic anxieties, in fragments, which could scarcely be paralleled, inasmuch as it is more in times of pressing anxiety and of sudden emergency, as I have said, that the public invoke our aid, as they call in that of the physician in times of bodily ailment. These anxieties are sometimes of an amusing character; at other times are most painful. We have *ordered* a turbot, and also a coffin; a dinner, and a physician; a monthly nurse, and a shooting-jacket; a special engine, and a chain-cable; an officer's uniform, and some Wenham-lake ice; a clergyman, and a counsellor's wig; a royal standard, and a hamper of wine; and so on. Passing over the black leather bag which some

one every day appears to leave in some train, passengers have recovered luggage of most miscellaneous character by means of the telegraph. In the trains have been left a pair of spectacles, and a pig; an umbrella, and *Layard's Nineveh;* a purse, and a barrel of oysters; a great-coat, and a baby; and boxes and trunks, *et id genus omne,* without number.

127. *French Revolution.*—The services rendered to the public by the electric telegraph during the several stages of the last French Revolution were very great. The earliest news of the actual catastrophe reached England by a pilot boat, and the alarming tidings forthwith were transmitted to the metropolis. From that time, and day by day, and with little cessation, a continued stream of intelligence passed up to London along the magic wire; and while the Chairman and Directors of this railway remained by day and night in charge of the telegraph station at London, that by their presence every facility might be afforded to the Government, to the press, and to the public, in this time of excitement, the Superintendent of Telegraphs took charge of the coast stations of Dover and Folkstone, to receive the relays of intelligence as they arrived, and direct their transmission to London. In this way every successive scene in the revolution, as well as in its offspring in other continental countries, found its way to London *first* by this line of telegraph; and many and most important arrangements in return were made at the coast towns in connection with these events.

128. The week throughout was wet and stormy, and as bad for telegraph purposes as weather could well be, and the gutta-percha wires were not then up in the tunnels. We were also actually transferring some part of the wires off the viaduct into the gardens at Bermondsey at the very time the news was first passing along them, and

yet no delay, nor error, nor disappointment occurred. All the despatches entrusted to us passed in turn along the wires, and safely reached their destination.

129. I have said it would not be easy to reduce our rates so low as to rival the Post-office, and obtain a large increase of business, nor do I think such a state of things to be coveted, For our character would then be at stake; everybody would have to wait till somebody else's message was sent, and the telegraph, instead of being for the most part ready at a moment's notice, or with no great delay to all comers, would be always found occupied, and messages would be retained so long before their turn arrived to be sent, that the true essence of the telegraph would be to all intents and purposes lost.

130. *Telegraph Messages.*—The following list, which is far from complete, will give some idea of the miscellaneous character, and the multiplicity of the service required of the telegraph:—

Accidents
Announcements
Appointments
Arrivals
Arrests
Bankers
Beds
Bills
Births
Commotions
Counsel
Couriers
Crops
Customs
Deaths
Departures
Despatches
Elections
Elopements
Expresses
Funds and Shares
Government
Health
Hotels
Judgments
Lost luggage
Markets
Medical aid
Meteorology
Missing trains
Murders
News
Nurses
Orders
Passengers
Payments
Police
Political
Post-horses, &c.
Reporters
Remittances
Respite
Robberies
Royal movements
Sentences
Shipping news
Ship-stores
Turf
Witnesses
Wrecks

131. On inspecting this list, what internal evidence does it not present of the confidence that is reposed by the public in the telegraph! To post a letter to our

dearest friend, filled with our heart's most secret thoughts, —to confide such a document to the hands of strangers, to men whom we have never seen, and of whom personally we know nothing, has been given as a fine illustration of faith; in this case, of faith in the integrity of the institutions of our country. But the letter-carrier knows not the joys or sorrows of which he is the bearer; far otherwise with the telegraph, we are taken into the confidence of the public, and are made conscious of the tidings we convey. That this confidence has not been held to be misplaced, may be gathered from the steady and progressive increase in the number and value of the despatches entrusted to us.

I am not far from the truth in stating the telegraph dividends on the South-Eastern Railway to have been $1\frac{1}{10}$, $3\frac{1}{2}$, $2\frac{4}{5}$, and $3\frac{3}{5}$ per cent. per annum, for the four half years ending respectively January and July 1848 and 1849, after all expenses of working and maintenance were paid. In addition to which, and of which no account enters into the above calculation, are the invaluable services of the telegraph to the railway itself (§ 112, &c.), already in part described.

132. THE ELECTRIC TELEGRAPH COMPANY. — The lines of telegraph that have served as our illustration are, as I have said (§ 51), the property of the South-Eastern Railway Company. They were erected for them by the "ELECTRIC TELEGRAPH COMPANY," to whom belong the patent rights of these and many other inventions for transmitting signals by electricity. The Telegraph Company, however, have erected for themselves, and work and maintain, a most extensive system of telegraphs; their stations being to be found in almost all parts of the kingdom, and they are still increasing them.

133. They were incorporated by Act of Parliament

passed June 18, 1846. They have power to purchase letters patent, which patents may be prolonged to them, should the Crown think fit: they may grant licences to use such patented inventions, or they may sell, let, or dispose of their telegraphs. They are required to grant any one named by the Privy Council a license to construct and use a telegraph, upon terms to be agreed on, for the service of Her Majesty's Government, should they be duly applied to for such. In addition to this, every electric telegraph "shall at all reasonable times be open for the transmission of intelligence for Her Majesty's service;" "and all messages at any time sent to any station of the Company for transmission and delivery on or for Her Majesty's service shall have priority over all other messages whatsoever; and that it shall be imperative on the Company, and their officers and servants, to transmit and deliver such messages accordingly, and to suspend the transmission of all or any other messages from such station, until the said messages on or for Her Majesty's service shall first have been transmitted;" for which reasonable remuneration is to be made. That in times of emergency, it shall be lawful for one of the Secretaries of State to cause possession to be taken of all the telegraphs and apparatus at the various stations of the "Company, their licencees, or assigns," for one week, and to retain them week by week, if expedient for the public service, paying for them the average weekly earnings.

134. The Act makes provision for the Company against the negligence or carelessness of their officers or others; and furnishes them with the necessary powers for erecting and maintaining their apparatus. Although this Act has not been in force more than three and a half years, their operations have already extended over a district of 2,225 miles: they have erected 482 double-needle instruments,

and 86 single-needle; and more will have been added before this book is in the hands of the reader.

135. *List of Lines of Telegraph.*—The following statistic details are correct, to the time of writing:—

Name of Railway.	No. of Miles.	No. of Wires.	No. of Double Needle Insts.	No. of Single Instruments.	Length of Street Line.
Edinburgh and Glasgow ..	47½	5	8	..	⅛
Tunnel Line	1	2	2	..	..
Edinburgh and Northern.					
Dundee Branch	36	3	6	..	..
Perth Branch	6	3	..	..	..
Edinburgh and Granton	3	3	3	..	..
Leith Line	1½	3	3	..	..
Tunnel Line	1	2	2	..	..
North British	58	5	8	..	..
Dalkeith Branch............	1¼	2	2	..	..
Haddington Branch	5	2	2	..	..
Tunnel Line	1¾	2	2	..	..
York, Newcastle, & Berwick.					
Newcastle to Berwick	65½	5	7	..	..
York to Darlington	45	7	6	9	..
Darlington to Newcastle	38½	8	6	8	⅛
Shields Branch	11	3	2	..	..
Sunderland Branch	2¼	3	2	..	..
Durham Branch	2¼	2	1	..	..
Richmond Branch	9	2	1	..	..
Fatfield and South Shields ..	19	1	..	4	..
Stockton Branch	½	1	..	2	..
York and North Midland.					
Normanton to York	24½	..	5	..	..
York to Scarborough........	42½	3	5	..	..
Harrogate Branch	18	3	2	..	..
Hull and Selby	36	5	5	..	⅞
Hull and Bridlington........	33	3	4	..	..
Normanton to Milford Junction	10	2	2	..	..
Carry forward......	519	..	86	23	1⅛

Name of Railway.	No. of Miles.	No. of Wires.	No. of Double Needle Insts.	No. of Single Instruments.	Length of Street Line.
Brought forward......	519	..	86	23	1⅛
Manchester and Leeds	51	7	24	..	..
Preston and Wyre	20	3	4	..	..
Liverpool and Southport	13¼	3	3	..	..
EAST LANCASHIRE	12½	3	..	..	..
MIDLAND RAILWAY.					
Birmingham and Gloucester ..	53	7	9	..	..
Birmingham and Derby......	6½	7	5	1	..
Do. Do.	34¾	5			
Derby and Lincoln..........	48¾	3	4	..	..
Derby and Rugby	24½	7	7	..	..
Do. Do.	24¾	5			
Leicester and Peterborough ..	4¾	3	11	..	..
Do. Do. ..	23	5			
Do. Do. ..	25¼	7			
Derby and Leeds	73	7	9	16	..
Sheffield Branch............	5	3	2	..	..
Leeds and Bradford	11	6	5	..	..
Do. Do.	2¾	3			
Do. Do. Tunnel Line	1½	2	2	..	..
Skipton Branch	15¼	3	5	..	..
LONDON AND NORTH-WESTERN.					
London to Birmingham......	5	9	9	1	..
Do. Do.	107½	7			
Do. Do. Tunnel Line	1	3	2	..	..
Do. Do. Camd. Incl.	1¼	6	4	2	..
West London Junction	½	2	4	..	..
Birmingham and Manchester	80	7	6	1	⅛
Do. Do. ..	5	8			
Ardwick Junction	3¼	8	..	..	..
Manchester and Liverpool....	31½	6	5	..	⅞
Do. Do. Tunnel Line	1½	2	3	..	..
SOUTH-DEVON	53	4	10	..	..
Torquay Branch	4	3	2	..	..
NEWMARKET RAILWAY	17	5	4	..	..
Carry forward......	1280	..	225	44	2⅛

NAME OF RAILWAY.	No. of Miles.	No. of Wires.	No. of Double Needle Insts.	No. of Single Instruments.	Length of Street Line.
Brought forward......	1280	..	225	44	2⅛
EASTERN UNION	16¾	5	7	..	..
Do. Do. Tunnel Line	2¾	2	3	..	..
LONDON AND SOUTH-WESTERN.					
London to Southampton	74	4	4	..	..
Do. Do.	6	6	2	..	..
Portsmouth Branch	21	4	4	..	..
Gosport Branch	5	4	1	..	..
Southampton and Dorchester	61	3	7	..	..
Poole Branch	2	3	2	..	..
EASTERN COUNTIES.					
London to Brandon	88¼	7	40	..	..
London to Stratford	3¾	2	4	..	..
Brick-lane Line	½	2	3	..	..
Enfield Branch	3¼	2	2	..	..
Hertford Branch	7	3	3	..	..
Cambridge and St. Ives......	14¾	3	5	..	..
Ely and Peterborough	30	5	7	..	..
March and Wisbeach	9	3	2	..	..
London and Colchester	51¼	5	13	..	..
Forest-gate and Stratford	1¼	1	..	2	..
Maldon and Braintree	12	3	3	..	..
Stratford and Thames Junction	2¾	3	2	..	..
North Woolwich............	2¾	3	2	..	..
NORFOLK RAILWAY.					
Brandon to Norwich	37¾	7	19	..	..
Do. Do.	10¼	1	..	7	..
Norwich and Yarmouth......	20	9	..	..	..
Lowestoft Branch	12	5	..	..	..
Dereham Branch	12	3	2	..	..
Dereham and Fakenham	12¼	2	2	..	..
NORTH STAFFORDSHIRE.					
Stoke to Norton Bridge......	10¾	3	3	..	..
Colwich Branch	18¾	2	2	..	–
Stoke to Burton............	29¼	3	5	..	..
Do. Do. Goods Depôt	¾	2	2	..	..
Carry forward......	1858 11/16	..	376	53	2⅛

NAME OF RAILWAY.	No. of Miles.	No. of Wires.	No. of Double Needle Insts.	No. of Single Instruments.	Length of Street Line.
Brought forward......	1858 11/12	..	376	53	2⅛
NORTH STAFFORDSHIRE (*cont.*)					
Stoke to Crewe	14½	3	4	..	..
Harecastle Tunnel Line......	1	2	2	..	..
Macclesfield Branch	19½	3	4	..	..
Churnet Valley	27	2	..	..	..
SOUTH STAFFORDSHIRE.......	9¼	2	3	..	..
Do. Do.	2	3	1	..	..
NORTHAMPTON & PETERBORO'	47	3	10	..	..
Do. Extension to Wolverton	10½	4	2	..	..
London and Croydon..........	8	3	4	..	..
Great Western	19	4	2	..	..
London Street Lines	..	various	10	..	7¾
Manchester and Sheffield	2	3	3	..	..
Do. Woodhead Tunnel Line	3¼	3	2	..	..
Ambergate, Matlock, and Buxton	11½	2	3	..	..
London and Blackwall	3½	..	..	..	..
Caldon-Low Quarry Line	3¼	1	..	4	..
Moira Colliery	½	2	2	..	..
Maryport and Whitehaven	½	4	4	..	..
Butterley Iron Company's Line	2½	1	..	2	..
SOUTH-EASTERN.					
London to Dover	88		11	18	..
London to Rochester........	31	4	18	..	..
London to Bricklayers' Arms	4	2	2	..	..
Tunbridge to Tunbridge Wells	5	3	2	4	..
Tunbridge to Hastings Road..	1	2	2	..	⅛
Tunbridge to Laboratory	..	1	..	2	..
Paddock Wood to Maidstone	10	3	5	..	..
Ashford to Ramsgate........	30	3	5	..	..
Minster to Deal	9	3	3	3	..
Ramsgate to Margate	4	3	2	..	..
Total	2225⅔	..	482	86	10

136. *Telegraph Stations.*—Of the telegraph stations to be found on these various lines, the following is a list:—

List of Telegraph Stations.

Abbey Wood
Alnwick
Ambergate
Ashford
Barnsley
Berwick-on-Tweed
Beverley
Birmingham
Bishopstoke
Blackheath
Bradford
Bridlington
Broxbourne
Burton-on-Trent
Cambridge
Canterbury
Charlton
Chelmsford
Cheltenham
Chesterfield
Chilham
Colchester
Darlington
Dartford
Deal
Derby
Dover
Dunbar
Durham
Edenbridge
Edinburgh
Ely
Erith
Farleigh
Folkstone
Glasgow
Gloucester
Godstone
Gosport
Gravesend
Greenhithe
Halifax
Headcorn
Hertford
Hull
Hythe
Ipswich
Leeds
Leicester
Leith
Lewisham
Lincoln
Liverpool
London
Loughborough
Lowestoffe
Maidstone
Malton
Manchester
March
Marden
Margate
Melton
Merstham
Minster
Morpeth
Newark
Newcastle
Newmarket
Norwich
Normanton
Northallerton
Northfleet
Nottingham
Paddock Wood
Penshurst
Peterborough
Pluckley
Ramsgate
Reigate
Rochester
Rochdale
Romford
Rotherham
Rugby
Sandwich
Scarborough
Selby
Sheffield
Skipton
Slough
Southampton
South Shields
Staplehurst
Stamford
St. Ives
Stortford
Sunderland
Tamworth
Thetford
Thirsk
Todmorden
Tonbridge
Tunbridge Wells
Wakefield
Ware
Wateringbury
Wisbeach
Witham
Woolwich
Worcester
Yarmouth
York

137. As my purpose has been to describe the existing telegraph systems of England, I do not feel called upon, nor have I space, to describe the other patented inventions

belonging to the Telegraph Company; nor to give a list of the large number of very ingenious contrivances that still remain private property. As, however, "Bain's Printing Telegraph" has been lately in use between Birmingham and the Company's station in Lothbury, I should mention that it receives signals by means of a ribbon of paper moistened with some chemical solution that is decomposed, and that presents a stain, by the action of an electric current. The ribbon is drawn on by mechanism, and the current is sent by the hand, or by mechanism; a combination of short and longer currents, producing dots or strokes, constitute the alphabet.

138. SUBMARINE TELEGRAPH.—This is a somewhat unfortunate term, for it leads the multitude to think of some peculiar kind of instrument, more fitted than others, for propelling telegraphic signals beneath the ocean-wave. The only thing *submarine* in it is the conducting wire; and when this is *in sitû* it matters little, as far as the submarine part of the affair is concerned, what generator of an electric current, or what interpreting instrument, is at each end. Insulated as we are from other nations, and yet very deeply interested in all that transpires on the Continent, we naturally look forward to the day when telegraph communications shall be made with as much facility between Dover and Calais, and Folkstone and Boulogne, as they now are between London and Dover.

139. The first step has been taken; the first stage has been passed; signals from London have been transmitted to the coast at Folkstone, and onward by two miles of covered wire, submerged beneath the waters to the deck of a vessel afloat; and conversation has so been held. This was on Jan. 10, 1849; and, as the day will assuredly come, but not just now, when this embryo invasion of Neptune's domain, shall become a practical reality, it may

be well to have a faithful record of the circumstances connected with this experiment.

Having watched for some time, and occasionally assisted in the perfecting a wire covered with gutta percha (§ 39), for tunnel use, I readily obtained the permission of the Directors of the South-Eastern Railway Company to employ it for insulation in our several wet tunnels. It occurred to me, as the work went on, that I possessed unusual facilities for a submarine experiment—a line of railway from London to the coast, a harbour under the same Direction as the railway, a fleet of steam ships occupying this harbour, equally accessible, and several miles of wire covered with a perfectly insulating material. It is true the season (January) was not favourable, but it was not convenient to delay. I explained my views to the Board of Directors, and had no difficulty in obtaining their countenance and assistance. They fixed the day, they ordered a steam-ship to be at my command, and they issued cards of invitation, including free transit from any part of the railway, or from Calais and Boulogne to Folkstone and back, and available for several days.

140. I selected upwards of two miles of No. 16 copper wire, provided with its coat of gutta percha; I personally tested the whole, piece by piece, under water, and also the several joints. It was then wound on a wooden drum, mounted on a frame, and so conveyed to Folkstone.

The sketch of Folkstone Harbour (see frontispiece) will illustrate our experiments. From the main line of railway a branch, of about a mile in length, descends to the harbour, crossing to the station by the swing bridge shewn in the drawing. The telegraph office is the last room in the low range of buildings next beyond the station. We are obliged to avoid the bridge with the wires, since masted vessels have to enter the inner harbour; and hence we lead them a circuitous course behind the Pavilion Hotel and the Harbour House. I erected a pole in the sands just above high water-mark, by which I led a wire from the telegraph office to the margin of the sea. On the evening of the 9th, I, for the last time, tested the continuity of the wire, by placing the drum on the sands and connecting the covered wire with the wire that led from London; and then, with the ripple at our feet, and by the glare of lamps, amid a motley and wondering group of fishermen, seamen, revenue officers, and others, we proved the *circuit* was good, by holding converse with the clerks at London.

141. Our plan, for the morrow, was to take the drum out in a small boat, somewhat in a direct line from the shore, uncoiling and submerging the wire as we went on; and there to have remained at anchor, till the time of the arrival of the train from London, when the steamer was to sail out with our friends to the position shewn on the right, and, having the telegraph apparatus on deck, was to take us on board, with the end of the wire. But the aspect of nature changed during the night; the wind arose, and the sea became so disturbed, that not only would it have been a fruitless task for landsmen to have attempted philosophical illustrations on so unstable a theatre as a ship tossing on the waves, but it would have been practically impossible to have avoided snapping the wire. Instead, therefore, of the ship going out to the boat, the latter went out alone, paying out the wire in its progress, according to the original plan, and returning with the end to the shore. The wire was the upper one of the four; it was continued in a direct line from its present termination by the gutta-percha wire, which was carried over the pier into the sea, and paid out in front of the harbour; and passing in at the mouth of the harbour, it terminated at the instrument on the deck of the steamer moored alongside the pier, in the place shewn in the drawing. The conditions of the experiment were, therefore, all complied with, although the *effect was not so striking* as if the ship should have gone out to receive the end of the wire.

142. It had previously been arranged that the telegraph business for this day should be conducted on one wire (No. 2), leaving No. 1 at liberty for these experiments. The Folkstone end of this wire, as I have said, was joined to the submerged wire, the other end of which was also now connected with a single needle instrument on deck, and the circuit was completed by an earth-plate dropped overboard.

143. These operations were done in presence of our guests, who were now on board; there was no *rehearsal*, and the wire was meanwhile being buffeted by the waves against the pier. I must confess I felt a little uneasy at having called so many witnesses so far from their homes to an experiment, which could be but partially tested in advance, and the first perfect trial of which would be made publicly. I knew that a slight defect of insulation would not have marred the experiment had the two miles of submerged wire alone been in circuit, but when to this was added the eighty-three miles of wire between the coast and London, I was aware that flaws would be fatal. All being ready, I took the handle of the instrument and made the letter L, the call for London; the acknowledgment of the call was instantaneous; and at forty-nine minutes past noon the first telegraph despatch passed beneath the British Channel in direct course to London; it was "Mr. Walker to Chairman,—I am on board the *Princess Clementine*: I am successful." Immediately upon this a correspondence was kept up with London. Communications were then interchanged with other stations on the main line, and after several hours immersion, the wire was drawn up safe

and sound. It is now in its place in Merstham tunnel, and has been the channel through which all our important despatches have since reached London.

144. In the map (Fig. 9, § 51) I have given the contours of the French coast, and the soundings in fathoms of the part of the Channel between Folkstone and Boulogne, showing also the two banks facing Folkstone. I have also dotted out some courses for a submarine wire. It must not be supposed that we should in practice attempt to employ so slender and so unprotected a wire in an actual circuit across the channel; nor must it be imagined that because no further steps have been taken, any insurmountable engineering difficulties have presented themselves; but there are difficulties of another kind, and while they exist there is little probability of the attempt being made. I allude to the policy of the French Government, which retains to itself the use and control of telegraphs in France; so that, if even they allowed a telegraph wire to arrive at their coasts, the advantage of saving the mere sea passage of two hours would be by no means adequate to the grandeur and expense of the undertaking. We must hope that time and circumstances will ere long change this policy, and that they will be enabled to permit the public to have as free use of the telegraph in France, and with as much safety as we have in England; and then, in a future edition of this book, we shall be able to examine the plan that may be pursued for traversing the Channel. The French writers on Electric Telegraphs strongly urge the removal of these restrictions. Even while these sheets are passing through the press, the matter has been named in the "Legislative Assembly" of France. A committee, who had reported on the 4th of February 1850, upon the propriety of establishing certain lines of Electric Telegraph upon some of the French

Railroads, and had recommended a grant of money for that purpose, inquired of the Minister of the Interior whether it was his intention to allow the use of the Electric Telegraph to the public, as his predecessor, M. Dufaure, had proposed. The Minister replied, that *it was a serious question on which he could not decide until he had received further information.* It is not for us, nor is this the place, to enter upon the merits of this question, in as far as it is connected with the Government of France, nor would it be becoming in us to attempt to determine how far France may be prepared for so decided and so important a concession. We have only to hope that such "further information" as may be gathered by the committee, and presented to the Assembly, may be of so favourable a tendency as to lead to a gradual abolition of the restrictions which prevent the French merchant and the French citizen deriving advantage from this wonderful scientific application.

145. Without entering upon the internal relations that may be involved in this question, it would appear that much good must result every way to all parties by the capital of the British empire being within "ear-shot," so to say; within "speaking distance" of the capitals of the other great kingdoms of Europe. We have done our part; we have extended the wires from London to the very sea-shore, to within half a dozen paces of the very landing-place of the chief thoroughfare between England and France. The first "bureau" that meets a foreigner's eye on landing in England is the telegraph-office at Folkstone, which is open, without favour or preference, to the first comer. A few steps across the pier, and he has the means, for a moderate charge, of immediate communication with London; and hence with all the chief towns in the kingdom. And the day may be nearer than we believe when our

neighbours on the other side the Channel shall do as much for us: when the wires that are now laid from Paris to Calais may be equally accessible to the public as they are here. If the ready intercommunication that now exists between London and Paris by railways and steam-ships has so greatly promoted the growth of kindly feelings between the citizens of the two countries, how much more may not these friendly dispositions be confirmed when we shall each feel that we can interchange our thoughts with lightning-speed?

THE END.

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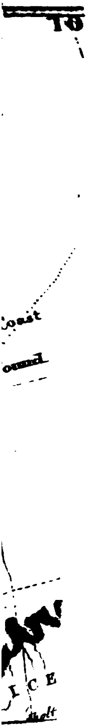
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